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EDITOR OF THE MONTH

FRED B. MOOR, M.D.

Los Angeles, Calif.

Printed in U. S. A.

POSTGRADUATE COURSE IN PHYSICAL MEDICINE AND REHABILITATION

UNIVERSITY OF TEXAS — MEDICAL BRANCH, GALVESTON

MARCH 3-7, 1947

TENTATIVE PROGRAM

Monday, March 3rd —

8:30	Registration for the Course	
9:00	Opening Remarks and Introduction of Guest Speakers	
9:15	Physiologic Basis for Therapeutic Heat and Cold	Selle
9:45	Local Application of Heat (with Demonstrations)	Martin
10:30	Physiologic Basis for Physical Medicine	Boynton
11:00	Therapeutic Exercise	Elkins
1:30	Instructional Period: Physics of Medical and Surgical Diathermy	Holmquest
2:00	Injuries of the Hand	Watkins
2:30	The Care of the Weakened Shoulder	Bennett
3:00	Physical Medicine in Its Application to Tuberculosis and Prevention of Deformities Following Thoracoplasty	Kuitert
3:30	Headache which Responds to Physical Therapy	Selke
4:00	Ultraviolet Therapy	Kovács
5:00	Movie — Local Application of Heat	

Tuesday, March 4th —

8:30	Instructional Period: Electrodiagnosis	Watkins
9:30	The Present Status of Fever Therapy	Elkins
10:00	Assistive and Supportive Apparatus in the Treatment of Muscle, Nerve Injuries	Bennett
10:30	Physical Medicine in the Treatment of Fractures	Ober
11:00	Low Backache	Eggers
11:30	Physical Medicine in Institutional Practice	Kovács
1:30	Instructional Period: Ion Transfer	Martin

PHYSICAL MEDICINE IN GENERAL PRACTICE AND THE MEDICAL SPECIALTIES

2:00	Physical Medicine in Orthopedic Surgery	Ober
2:30	Physical Medicine in General Surgery	Poth
3:00	Physical Therapy in Relation to Military Medicine	Kuitert
3:30	Physical Medicine in Neurology	Watkins
4:00	Physical Medicine in Peripheral Vascular Diseases	Herrmann
4:30	Physical Therapy in Dermatology	Frazier
4:45	Physical Medicine in General Practice	Piersol
5:15	Movie on Hydrotherapy	

Wednesday, March 5th —

8:30	Instructional Period: Massage and Hydrothermal Measures	Bennett

Wednesday, March 5th — (Cont.)

SYMPOSIUM ON ARTHRITIS ..... Piersol, Chairman

9:30 Statement of the Problem, Classification ..... Piersol
9:50 Physical Signs and Laboratory Findings ..... Gregory
10:10 Morbid Anatomy (Pathology Department) ..... Winsett
10:30 X-Ray Findings ..... Schneider
10:50 Differential Diagnosis ..... Stone
11:10 Temperature-Circulatory Studies in Arthritis ..... Martin
11:30 General Discussion
12:00 Closing Remarks ..... Piersol

1:30 Movie — Exercise

Treatment

2:00 a) Value of Diet, Climate, Drugs and Spa Therapy ..... Diederich
2:45 b) Physical Measures
1) X-Ray ..... Schneider
2) Heat and Counterirritants ..... Kovács
3) Rest, Massage, Exercise ..... Piersol
4:15 c) Orthopedic Measures ..... Ober
5:00 d) General Discussion

Thursday, March 6th —

8:30 Instructional Period: Muscle Testing and Muscle Reeducation ..... Bennett

SYMPOSIUM ON POLIOMYELITIS ..... Watkins, Chairman

9:30 Epidemiology ..... Pollard
10:15 Electromyographic Studies in Poliomyelitis ..... Watkins
10:45 Current Trends in Poliomyelitis ..... Van Riper
11:45 Discussion Period

Treatment

2:00 a) Value of Drugs ..... Van Riper
2:30 b) Physical Therapy, Early (Acute) Stage ..... Piersol
3:00 c) Responsibility of Physical Medicine in the Convalescent Stage ..... Bennett
4:00 d) Orthopedic Procedures in Chronic Poliomyelitis ..... Ober
4:45 General Discussion Period
5:00 Movie — "Accent on Use" (National Foundation Film)

Thursday Evening —

Banquet — Hotel Galvez ..... Chauncey D. Leake, Toastmaster
Relation of Physical Medicine to General Practice ..... Piersol
Activities of the National Foundation for Infantile Paralysis ..... Basil O'Connor

Friday, March 7th —

8:30 Instructional Period: Aspects of Prescribing Physical Medicine ..... Elkins

REHABILITATION ..... Eggers, Chairman

9:30 Physical Therapy in Peripheral Nerve Injuries ..... Kovács
10:00 Occupational Therapy and Rehabilitation ..... Brown
10:30 Rehabilitation of the Neuropsychiatric Patient ..... Ewalt
11:00 Physical Medicine and the Medical Rehabilitation Program of the Veterans Administration ..... Covalt
11:45 Physical Medicine in Civilian Rehabilitation ..... Speaker to Be Announced

Friday Afternoon —
Excursion to Houston. Dinner at San Jacinto Inn

Saturday, March 8th —
Deep Sea Fishing (40 miles out in Gulf) for those interested

For further information regarding the course write to W. A. Selle, Professor of Physiology, Chairman. Postgraduate Course in Physical Medicine, University of Texas, Medical Branch, Galveston.

APPROVED SCHOOLS FOR PHYSICAL THERAPY TECHNICIANS ‡

Council on Medical Education and Hospitals of the American Medical Association

Name and Location of School	Medical Director	Technical Director	Entrance Requirements *	Duration of Course	Time of Admission	Maximum Enrollment	Tuition	Certificate, Diploma, Degree
Children's Hospital, Los Angeles[1]	Samuel Mathews, M.D.	Miss Lily Graham	a-b-c	14 mos.	Sept	14	$200	Diploma
College of Medical Evangelists, Los Angeles[1]	Fred B. Moor, M.D.	A. H. Carlson	a-b-c-d	12 mos.	Sept	20	$225	Cert. or Dipl.
University of California Hospital, San Francisco[1]	Frances Baker, M.D.	Miss Margery L. Wagner	a-b-c	12 mos.	MarchSept	10	$150	Certificate
Stanford University, Stanford University, Calif.[1]	W. H. Northway, M.D.	Miss Lucille Daniels	a-b-d	10 mos.	Quarterly	16	$409	Cert. or Degree
Northwestern University Medical School, Chicago	John S. Coulter, M.D.	Miss Gertrude Beard	a-b-d	12 mos.	JulyOct	16	$300	Certificate
State University of Iowa Medical School, Iowa City	W. D. Paul, M.D.	Miss Olive C. Farr	f	12 mos.	Sept	....	$200	**
University of Kansas School of Medicine, Kansas City[1]	G. M. Martin, M.D.	Miss Ruth G. Monteith	a-b-c[2]	12 mos.	FebSept	20	$ 50[3]	Cert. or Degree
Bouvé-Boston School of Physical Education, Boston	Arthur L. Watkins, M.D.	Miss Constance K. Greene	c[4]	10 mos.	Sept	15	$250[5]	Cert. or Degree
Boston University, College of Physical Education for Women, Sargent College, Cambridge, Mass.	Louis Howard M.D.	Miss Adelaide L. McGarrett	H.S.	4 yrs.	Sept	20	Varies	Cert. or Degree
University of Minnesota, Minneapolis[1]	M. E. Knapp, M.D.	Miss Ruby Green	H.S.	4 yrs.	Oct	12	$530[3]	Degree
Barnes Hospital, St. Louis	F. H. Ewerhardt, M.D.	Miss Beatrice F. Schulz	a-b-c	12 mos.	Oct	12	$200	Certificate
St. Louis University School of Nursing, St. Louis[1]	A. J. Kotkis, M.D.	Sister Mary Imelda	a[2]	10 mos.	Jan-Sept	12	$250 yr.	Cert. or Degree
Columbia University, College of Physicians and Surgeons, New York City[1]	William B. Snow, M.D.	Miss Josephine L. Rathbone	a-c[6]	2 yrs.	Sept	35	$400 yr.	Cert. or Degree
New York University School of Education New York City[1]	George G. Deaver, M.D.	Miss Elizabeth C. Addoms	a-b-d	12 mos.	Sept	40	$525	Cert. & Degree
Duke Hospital, Durham, N. C.[1]	Lenox D. Baker, M.D.	Miss Helen Kaiser	a-b-d	12 mos.	Oct	12	$300	Certificate
D. T. Watson School of Physiotherapy, Leetsdale, Pa.[1]	Jessie Wright, M.D.	Miss Kathryn Kelley	a-b-d	12 mos.	Oct	30	$200	Dipl. or Degree
Graduate Hosp. of the Univ. of Pennsylvania, Phila.[1]	G. M. Piersol, M.D.	Miss K. Sutherland	a-b-c	12 mos.	Sept	20	$200	Certificate
University of Texas School of Medicine, Galveston[1]	G. W. N. Eggers, M.D.	Miss Ruby Decker	a-b-d[8]	12 mos.[7]	Jan	6	$141[3]	Certificate
Baruch Center of Physical Medicine of the Medical College of Virginia, Richmond, in affiliation with Richmond Professional Institute[1]	F. A. Hellebrandt, M.D.	J. J. Buchanan, M.D.	a-b-c[2]	12 mos.†	Sept	20	$200[3]	Cert. or Degree
University of Wisconsin Medical School, Madison[1]	Elizabeth Grimm, M.D.	Miss Margaret A. Kohli	a-b-c[2]	12 mos.	Sept	20	$ 96[3]	Cert. or Degree
University Southern California, Los Angeles	O. L. Huddleston, M.D.	Charlotte Anderson	d[2]	12 mos.	Sept	16	$374	Certificate
Albany Hospital, Albany, N. Y.	John Ghormley, M. D.	Catharine Graham	a-b-c	9 mos.	Sept	6	$200	Certificate

* Courses are so arranged that any of the entrance requirements will qualify students for training. a = Graduation from accredited school or nursing; b = Graduation from accredited school of physical education; c = Two years of college with science courses; d = Three years of college with science courses; e = Four years of College with science courses; H. S. = High school graduation; f = degree in physical education or sciences.

† Currently eighteen Navy nurses are enrolled in a six-month emergency course.

1. Male students admitted.
2. High school graduates admitted to four-year course leading to degree.
3. Non-residents charged additional fee.
4. High school graduates admitted to four-year course leading to degree from Tufts College.
5. Tuition for degree course is $400 per year.
6. College graduates admitted to twelve-month certificate course.
7. Effective 1947 class.
8. Effective 1948 class.

‡ Reprinted in part J. A. M. A. 130:1156 (April 20) 1946.

** At the end of nine months the students can register in the graduate school for a degree of master of science in Physical Therapy.

THE GROWING IMPORTANCE OF PHYSICS IN THE PREMEDICAL AND MEDICAL CURRICULUMS *

FRANCIS O. SCHMITT, Ph.D.

CAMBRIDGE, MASS.

It is perhaps self-evident that physical science is assuming a rapidly growing significance in modern medical research and practice. The recent developments in nuclear science, electronics and physical instrumentation are particularly in the public eye at this time. However, the whole history of the evolution of preclinical and clinical fields shows an unmistakable trend which university and medical educators must properly understand if they would design curriculums for the effective training of the professional practitioner and researcher of the next generation.

In the remote past most of preclinical science was presided over by the department of physiology. There followed the splitting off of anatomy, biochemistry and pharmacology as knowledge in each of these fields accumulated. The boundary lines were not sharply drawn, nor do the present departmental domains represent a particularly logical pattern. Recently, with the rapid progress of biochemistry, particularly with respect to enzymes, hormones and intermediary metabolism, the biochemist has made conspicuous encroachments on the field of the physiologist. For example, in the problem of muscle contraction, recent biochemical advances have been spectacular. As the components of organisms yield to chemical isolation and characterization, this shift of approach is inevitable. The trend is also distinctly evident in many clinical fields.

But at the molecular and atomic levels the distinction between chemistry and physics is largely formal. The chemist may isolate a protein and eventually determine its amino acid composition, but for the investigation of its structure the full resources of physics must be invoked. Indeed, one of the most significant tasks of the biophysicist is the elucidation of the molecular and submolecular structure of the machinery of cells and tissues. And until knowledge of this structure is obtained, our understanding of the complex integration of energy-yielding reactions in protoplasm must remain nebulous.

The field represented by the Congress here assembled, physical medicine, must remain highly empiric until much advance has been made in our understanding of the interaction of temperature, light, electricity, magnetism and penetrating radiations with tissue and cellular systems. The reduction of the physical forms of therapy to a truly scientific basis must inevitably come late in the game. Many theoretic and experimental battles of biophysics and biochemistry must first be fought and won.

However, this is not to say that the effectiveness of present day physical therapeutic methods cannot be greatly increased by the application of well known physical principles. While the basis of such therapy may be empiric, it is at least possible to devise methods of measurement of the energy dissipated and the probable locus of its dissipation. For such purposes an understanding of physical measurements and physical instrumentation is necessary. Recent developments in these fields offer much promise if the appropriate liaison between physicists and practitioners of physical medicine can be established. Experience in the institution with which I am associated,

* From the department of biology, Massachusetts Institute of Technology.

* Read at the Twenty-Fourth Annual Session of the American Congress of Physical Medicine, New York, Sept. 6, 1946.

obtained under an arrangement sponsored by the Baruch Committee on Physical Medicine, is highly encouraging.

The examples cited are chosen as representative of basic medical science and of empiric clinical practice. Many other illustrations might be drawn from the fields of radiology, cardiology, psychiatry and so on. But the conclusion is clear. Biophysics is rapidly coming of age and must take its place with biochemistry and physiology in medical teaching and research, both at the preclinical and at the clinical level.

It is not my purpose to suggest or predict how this should or probably will come about. I suspect that, as in the case of biochemistry, there will be a peaceful penetration of biophysics. In some institutions the physiology or biochemistry departments will sponsor the new field; in others it will be the department of physical medicine. In still others there may be established a graduate department of physics or biophysics, the staff of which may deliver lectures on selected topics in various courses in the medical curriculum whilst engaging in research along lines of their own choosing.

It would be pointless to try to be more specific. All depends on the wisdom and understanding of the medical administrators who sponsor such programs and on the ability and personality of the biophysical pioneers who undertake such assignments. The main lines of strategy seem fairly evident; the tactics will vary with the genius and background of each institution.

It will be interesting to observe the roles of the medical schools and the university departments in the development of biophysics. In this country, at least, biochemistry originated in the academic chemistry departments as a logical extension of organic chemistry. When it became evident how powerful this approach to medical problems was destined to become, medical departments of biochemistry were organized, first in a few, then in all, first-class medical schools. The establishment of a strong professional society of biochemists further crystallized the field and determined the medical school as the most logical place for its development.

To what extent will this history be repeated in the case of biophysics? Many of the most significant biophysical research advances have sprung from the necessity of employing physical technics in the solution of fundamental physiologic problems. The use of electronic technics in neurophysiologic research is a striking example. Since the problems are biologic and medical in nature, it is perhaps logical that the initiative for the development of biophysics be taken by these departments. However, it will then be necessary to provide in these departments permanent academic positions sufficiently attractive to enlist first-class physicists or biophysicists on the staff.

Considerable interest in the subject has been manifested also by the physicists. In recent years symposiums on biophysics have been organized, somewhat sporadically, by the American Physical Society. In several universities the physics departments have sponsored teaching and research in biophysics with the view of establishing permanent faculty posts in the field. It is possible that at least some of these ventures will take firm root and become permanently established. This is perhaps most likely to be the case where the research activities center around problems which are highly technical in nature. The present preoccupation of physicists with nuclear research, coupled with the severe shortage of trained personnel occasioned by the war, may prevent many physics departments from embarking on a full scale program of biophysics, which they might otherwise be eager to espouse.

In all probability the pattern will be set by a few groups whose approach to the problem proves to be particularly effective. At the present it seems inevitable that what is required is collaboration between first-class men

trained in biology or medicine with equally able physicists and chemists. Each member of the group must be assured of a permanent position as attractive as he might expect in his own field. The collaboration must be entirely voluntary and natural rather than imposed. Since the fundamental problems are eventually biologic or medical rather than physical or chemical, it is logical that headquarters for such groups be located in biological or medical departments. Availability of funds to underwrite such fairly expensive organizations may, in certain cases, be the determining factor. The advantage of the university campus is the close proximity of the departments of biology, physics and chemistry.

The matters which I have been discussing have a very direct bearing on the second portion of our assigned topic, the role of physics in the premedical curriculum. The conviction has been growing that the instruction of premedical students in physics does not meet the needs of these students. The growing importance of physics in medical teaching, practice and research emphasizes the desirability of making this aspect of premedical training maximally effective.

Premedical training is offered by a wide variety of types of institutions, from the small college to the large university. At most of these institutions no special course in physics is offered for premedical students. Staff and facilities are lacking to provide courses designed specifically for these students.

The view has been expressed that the whole teaching program in physics and chemistry at the college level should be overhauled so as to develop these subjects in a more logical, integrated fashion. There is much to be said for this view, but the machinery of university organization is not such as to make such a sweeping reorientation realizable in the near future.

While the problem is very complex, it is not a new one. Professional medical and physical societies, including the Association of American Medical Colleges, the American Physical Society and the American Association of Physics Teachers, have appointed committees to bring in recommendations. Beginning with the Bliss, Williams and Klopsteg report, written over twenty years ago, these reports have presented the situation clearly and have offered several possible solutions. However, as yet these recommendations have received little more than polite attention.

Considering this subject basic to its interest in the application of physical principles and technic in the diagnosis and treatment of disease, the Baruch Committee on Physical Medicine has initiated action to bring to reality certain changes in the teaching of premedical physics, which were judged desirable.

After consultation with leading educators in the field of physics, it was concluded that much would be gained by certain modifications of the basic course in physics offered to premedical students and by developing a second year course of physics as applied in biology and medicine. In making these proposals, the Committee had in mind average premedical students, with their wide variety of academic backgrounds, aptitudes and abilities.

The premedical student who is above average in intellectual maturity has no more difficulty in grasping the concepts of physics, with its objectivity and precision of thought, than has the average student majoring in physics. But the average premedical student apparently finds himself pretty much at sea in the physics course and breathes a sigh of relief when the subject has finally been successfully passed. Commonly problems are negotiated by a frantic substitution of values for certain symbols found in the formulas given in the previous text assignment, rather than by a comprehension of

the principles involved. As judged by his performance in the physiology course, two or three years later, he has successfully forgotten what little was learned while taking the physics course.

If this is a reasonably accurate characterization of the average student, the purpose of the physics training has been all but lost. The student will not bring to his medical studies and his subsequent practice the objectivity and precision of thought, to say nothing of a broadened knowledge of the reasonableness of nature, which his training in physics should have provided.

Highly competent physicists have stated that the successful comprehension of physical matters requires special aptitudes, which, in general, are not possessed by the average premedical student. It is at least clear that the background in mathematics of this type of student is sufficient only for the comprehension of a descriptive rather than a quantitative type of course.

The difficulty lies not in degree of intelligence but in aptitude, preparation and, what may be most important, motivation. Many of these difficulties may be reduced by a revision of the mode of presentation of the material without alteration of the fundamental scope of the course. I am convinced that the premedical student enters the physics course with a desire to learn, even though he may have been warned by his less earnest fraternity brothers that the subject is an awful bore and apparently has nothing to do with medicine. He encounters a body of knowledge couched in academic language entirely foreign to his experience and, I fear, in many cases presented in a fashion unlikely to capture his imagination or stimulate his interest. Please remember that we are not considering the case of the exceptionally gifted student or the exceptionally effective instructor.

To help secure the interest of the student it was proposed that demonstration and lecture illustrations be drawn as much as possible from the biologic and medical fields. Thus many of the principles of mechanics may be illustrated as well by members of the body as by bridges, hoists and the like. Of course, the instructor must also be oriented in the professional field in which his students' interests lie. It was proposed that this might be accomplished by the preparation of a teaching manual of demonstration and laboratory experiments drawn from the biologic and medical fields. Since this would be best prepared by physics teachers themselves, the Baruch Committee requested the American Association of Physics Teachers to appoint a committee charged with the task of preparing such a manual. The request received favorable attention, and a committee, consisting of Dr. L. L. Barnes (Cornell University), chairman; Dr. L. I. Bockstahler (Northwestern University), and Dr. L. A. Strait (University of California) was appointed. This committee has undertaken to compile a source book of illustrative material with problems and experiments illustrating physical principles drawn from the fields of biology and medicine. The cooperation of all physicists and biologists will be sought, and it is to be hoped that all who have suggestions to offer will communicate with the committee or publish their suggestions in the *American Journal of Physics* or elsewhere.

Another aspect of physics which is becoming more and more important for doctors is the necessity of being familiar with the elements of physical instrumentation as exemplified in the technic used in diagnosis and therapy. Medical educators, including physiologists, radiologists and others, have agreed that most medical students are woefully lacking not only in an understanding of physical principles but also in the concepts of measurement and instrumentation.

Only the exceptional premedical student is sufficiently interested in physics to take advanced courses in the subject. The attitude of many medical colleges clearly discourages emphasis on scientific training, and the

premedical curriculum is already crowded with required and recommended subjects. Hence it seems unwise to suggest at this time that two years of physics be required of premedical students. This may be a minimum requirement in another generation, when biophysical research will have demonstrated the power of this approach to biologic phenomena.

However, at this time the Baruch Committee suggested that there be developed a second elective year course in physics, frankly of an applied nature in which the elements of measurement and physical instrumentation would be taught. Again, as much as possible, illustrations would be drawn from the biologic and medical fields. This course is not to be a dilute presentation of physiologic, radiologic and therapeutic technic given by a physicist totally unacquainted with biologic phenomena or by a member of the medical faculty whose staus in physics is at best that of an amateur. Rather, it would be an authoritative presentation of the theory of physical measurements and the interpretation of measurements made possible by modern instrumentation.

The committee of the American Association of Physics Teachers, referred to previously, is also considering the nature of this second year course for premedical students. In this case also, the committee proposes to prepare a syllabus of experiments and problems drawn from the fields of biology and medicine. The committee deserves the cooperation of physicists, biologists and medical educators in this valuable effort. Needless to say, the Baruch Committee on Physical Medicine is highly gratified that the professional physics teachers, through their Society's committee, are taking the steps necessary to implement the desired program, and the Baruch Committee bespeaks the cooperation of all of its medical colleagues in this valuable work.

As brought out previously, these recommendations are considered to be of a highly practical nature. In another day, when the philosophy of education in the natural sciences is more broadly conceived and more rationally brought to realization, such measures may be unnecessary. But at the present moment something of the sort appears to be highly desirable.

SCIENTIFIC EXHIBIT SPACE
25TH ANNUAL SESSION

A restricted number of scientific exhibits will be shown at the 25th Annual Session of the Congress. Applications will be accepted only for a limited time so please send in your request as soon as possible. Circumstances will make it necessary to accept only those deemed most worthwhile by the committee. Make your request to the executive officers of the Congress.

CROSS EDUCATION *

The Influence of Unilateral Exercise on the Contralateral Limb

F. A. HELLEBRANDT, M.D.

ANNIE M. PARRISH, B.S.

and

SARA JANE HOUTZ, B.S.

RICHMOND, VA.

The publication of DeLorme's[1] adaptation of weight-lifting procedures to the treatment of various disabilities of the skeletomuscular system led to a study of the rationale of the technic described.[2] In the course of the initial preliminary experiments, it was observed that unilateral exercise of the heavy-resistance type was associated with an apparent concurrent development of increased strength in the symmetric muscle groups of the unexercised contralateral limb. This phenomenon, referred to in the psychologic literature as "cross education," was subjected to considerable experimental investigation approximately fifty years ago. The object of the present study was to confirm and extend the earlier observations of the experimental psychologist, to discuss the genesis of the phenomenon in the light of recent advances in physiologic knowledge, and, reasoning from first principles, to consider the potential therapeutic utility of this finding.

The term "cross education" is credited to Scripture.[3] When it was first introduced, it was known that the practice of writing with one hand led to the unconscious acquisition of skill in the performance of symmetric movements by the opposite extremity, which wrote reversely, describing a mirror image of the movements performed by the limb which had been subjected to training. Scripture and his associates,[3] working in the Yale Psychological Laboratory, studied cross education experimentally in relation to the speed, strength and accuracy of relatively simple movements. Subsequently the crossed learning of more complex skills was explored in relation to the phenomenon of the transfer of training.[4] As far as could be determined from a review of the literature, cross education has never been put to the proof by the physiologist, and the phenomenon has not been utilized therapeutically.

Mode of Procedure

Subjects of the Investigation. — Fifteen normal, healthy, women ranging in age from 22 to 48 served as subjects. They varied in stature from 1.51 to 1.75 M. and in weight from 44.45 to 84.14 Kg. Six had had professional training in physical education, and

* From the Baruch Center of Physical Medicine, Division of Clinical Research, Medical College of Virginia.

* Read at the Twenty-Fourth Annual Session of the American Congress of Physical Medicine, New York, Sept. 6, 1946.

1. DeLorme, T. L.: Restoration of Muscle Power by Heavy-Resistance Exercises, J. Bone & Joint Surg. 27:645-667 (Oct.) 1945.

2. Hellebrandt, F. A.: Recent Advances in Methods of Hastening Convalescence Through Exercise, South. M. J. 39:397-401 (May) 1946. Houtz, Sara Jane; Parrish, Annie M., and Hellebrandt, F. A.: The Influence of Heavy Resistance Exercise on Strength, Physiotherapy Rev., to be published.

3. (*a*) Scripture, E. W.; Smith, T. L., Brown, E. M.: On the Education of Muscular Control and Power, Stud. Yale Psychol. Lab. 2:114-119, 1894. Scripture, E. W.; Cooke, W. C., and Warren, C. M.: Researches on Memory for Arm-Movements, ibid. 5:90-92, 1897. Scripture, E. W.: Cross-Education, *Appletons' Popular Sc. Monthly* 56:589-596 (March) 1900. (*b*) Davis, Walter W.: Researches in Cross-Education, Stud. Yale Psychol. Lab. 6:6-50, 1898; (second series), ibid. 8:64-108, 1900.

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8 were or had been affiliated with the armed forces. All but 2 were connected with the Baruch Center's physical medicine program, either as students or staff members. They were moderately active, accustomed to the rigors of physical work and familiar with the principles of scientific method. Cooperation was exceptionally good. Human research of the type which demands an "all out" physical effort is unreliable unless the subject is sufficiently interested in the project under study to continue work when the activity becomes difficult and unpleasant.

Heavy Resistance Exercise. — The experiments may be divided into three series. The first were based on the heavy resistance low repetition exercise procedure of DeLorme[1] as applied to the knee joint extensors and elbow joint flexors. On the initial day of observation, the 10 R.M. (repetition maximum) and the 1 R.M. were determined bilaterally with use of standard weight lifting equipment (iron boot and adjustable dumbbells).[5] Knee joint extension was performed according to the technic of DeLorme.[1] The official lift known as the "hand curl" was the basis of the upper extremity exercise.[6] It was modified slightly as to stance, to permit readier maintenance of balance during heavy unilateral exercise. Automatic postural adjustments necessary to compensate for the shift in the center of gravity of the body as a whole were allowed to take a natural, unrestricted course. After the initial so-called "limit day" observations, either the right or the left extremity was subjected to systematic training. During the first four days of each week, the subject performed 100 lifts composed of 10 consecutive bouts of 10 contractions each, starting with a load not less than one-half the 10 R.M. of the last limit day, and carrying the maximum load as nearly 100 times as possible. An "all out" effort was made on every fifth day, surpassing if possible the 10 R.M. and 1 R.M. of the previous week. No weight lifting was done on the sixth and seventh days.

Since the ability to perform repetitive work augments rapidly under the regimen described, most of the observations were confined to short periods of training, rarely exceeding four weeks in duration. On the final day of exercise, the ipsilateral and contralateral limbs were again subjected to limit day determination of the 10 and 1 repetition loads which could be lifted. Knowing the load lifted and the length of the bony lever actuated by the muscle group under study, total limit day work could be estimated in kilogram meters.

Unfortunately, no control experiments were performed, depicting the learning influence of the first upon the second trial when neither limb is subjected to practice in the interim intervening between trials. However, under the conditions of the experiment, retention of the effects accruing from the initial trial probably exerted a minimal influence upon the second trial, especially since there could be no control over the character of the interpolated physical activity. Motor learning presupposes a repetition of experiences in greater contiguity than that of these experiments.

In toto, 278 upper extremity weight-lifting experiments were performed on 14 subjects, with 56 lower extremity weight-lifting experiments performed on 4 subjects. The latter were discontinued because of the development of incapacitating knee joint pain in every subject. One, who had exercised seven times, was excluded from the series, because knee joint pain and swelling did not permit retesting. The power of the quadriceps of these healthy women appears to exceed the ability of the contiguous joint structures to resist the combined trauma of extreme muscular effort while sustaining the stress associated with the carrying of heavy loads.

Ergography. — The second series of experiments utilized a modified type of the Mosso finger ergograph. With the arm resting in an unrestrained supine position, the middle phalanx of the third digit was allowed to exert pressure against a bell-crank, thus lifting a constant load which could be varied by known increments as training progressed. The remaining fingers were prevented from flexing by well padded restraints placed on either side of the open space provided for the finger being exercised. Ergograms were recorded on a slowly moving kymograph. The distance through which the load was lifted was measured on a calibrated distance meter. Work done was calculated in kilogram meters. The subject contracted 60 times per minute to the rhythm of a metronome set at 120. The load was lowered slowly. Thus, contraction and relaxation were approximately equal in duration. No rest pauses occurred either at the height of the contraction or between lifts.

5. Obtainable from the York Barbell Company, York, Pa.
6. Hoffman, B.: Weight Lifting, York, Pa., Strength and Health Publishing Co., 1939.

The load selected was sufficiently heavy to result in a precipitous fatigue curve without evidence of plateauing in most subjects, even during the terminal phases of the training period. The load was so heavy that it was never carried without great effort. When the load could no longer be lifted because of fatigue, a sixty second rest pause was permitted. Exercise was then again resumed and continued similarly until the flexors of the middle finger had been exhausted 20 consecutive times. It required approximately thirty minutes to perform this bout of 20 all out efforts.

The exercise was invariably accompanied with visible swelling over the tendons and the belly of the digital flexors, followed by a sensation of tension, stiffness and pain. In several subjects, long-lasting numbness and paresthesias developed in one or the other neighboring digits from the force of the pressure against the restraints. Although only the middle finger was allowed to move, strong associated isometric contraction of the remaining digits of the ipsilateral hand inevitably occurred.

Bilateral observations were made on the initial and on the final day. Only the right hand was subjected to training. One hundred and seventy-two experiments were performed on 6 subjects, yielding in toto ergographic records of 3,440 fatigue curves. The period of observation varied from seventeen to forty-eight days. Most subjects exercised five days a week. All subjects demonstrated grossly evident hypertrophy of the exercised muscle.

Martin's Strength Test. — The third series of observations were incidental attempts to check, in a preliminary way, the validity of a single effort muscle test as a quantitative determinant of functional capacity. If systematic training increases the power to do repetitive work, is this reflected in the force which can be exerted in a single maximal effort? This raises obvious practical questions, since single effort muscle tests are among the most extensively used criteria for measuring patient progress under prescribed treatment.

The strength of the right and left elbow joint flexors and extensors of all but 1 of the 14 subjects performing the hand curl was measured before and at the end of training, the technic of Lovett and Martin[7] being used. In total 104 Martin strength test determinations were made.

Grip Strength. — The grip strength of the 6 subjects performing the ergographic experiment was determined bilaterally, before and after unilateral right-sided training, by means of a standard dynamometer. The average of three trials was accepted as the criterion for comparison. Since dynamometer studies had contributed to the early observations on cross education, the ipisilateral limb was allowed to make 3 maximal trials per diem, preceding the commencement of ergographic work. Thus, the 163 dynamometer tests composed of 3 trials each, or 489 maximal efforts, may be utilized for the study of cross education, as well as for exploratory validation purposes.

Results and Their Interpretation

The demonstrable evidence of cross education accumulated in this series of experiments is summarized in the table. Heavy resistance exercise of the quadriceps not only augmented the strength of the ipsilateral exercised side but had a striking concomitant effect on the contralateral limb, approximating or surpassing the influence of the prescribed unilateral volitional effort. This is illustrated in figure 1 *A*. Training to perform the hand curl had a similar influence (fig. 1 *B* and *C*). However, the magnitude of the crossed learning effect never exceeded that of direct practice. The maximal gain in the power to do repetitive work was elicited by ergographic exercise of the flexor digitorum profundus and sublimis (fig. 1 *D*). The associated cross education is illustrated in the accompanying kymograms (fig. 2). Negligible cross education occurred in 2 of the 6 subjects. One lacked the interest and will to make an all out effort (fig. 3). The other exercised against comparitively light resistance (fig. 4). The direct gain in strength as a result of squeezing the oval spring dynamometer was of an order comparable to that found in the published literature. When subjected to statistical analysis, the data yield a critical ratio of 2.33, indicating that the difference in strength as a result of practice is almost but not quite significant. However, the evidence

7. Lovett, R. W., and Martin, E. G.: Certain Aspects of Infantile Paralysis With a Description of a Method of Muscle Testing, J. A. M. A. 66:729-733 (March 4) 1916.

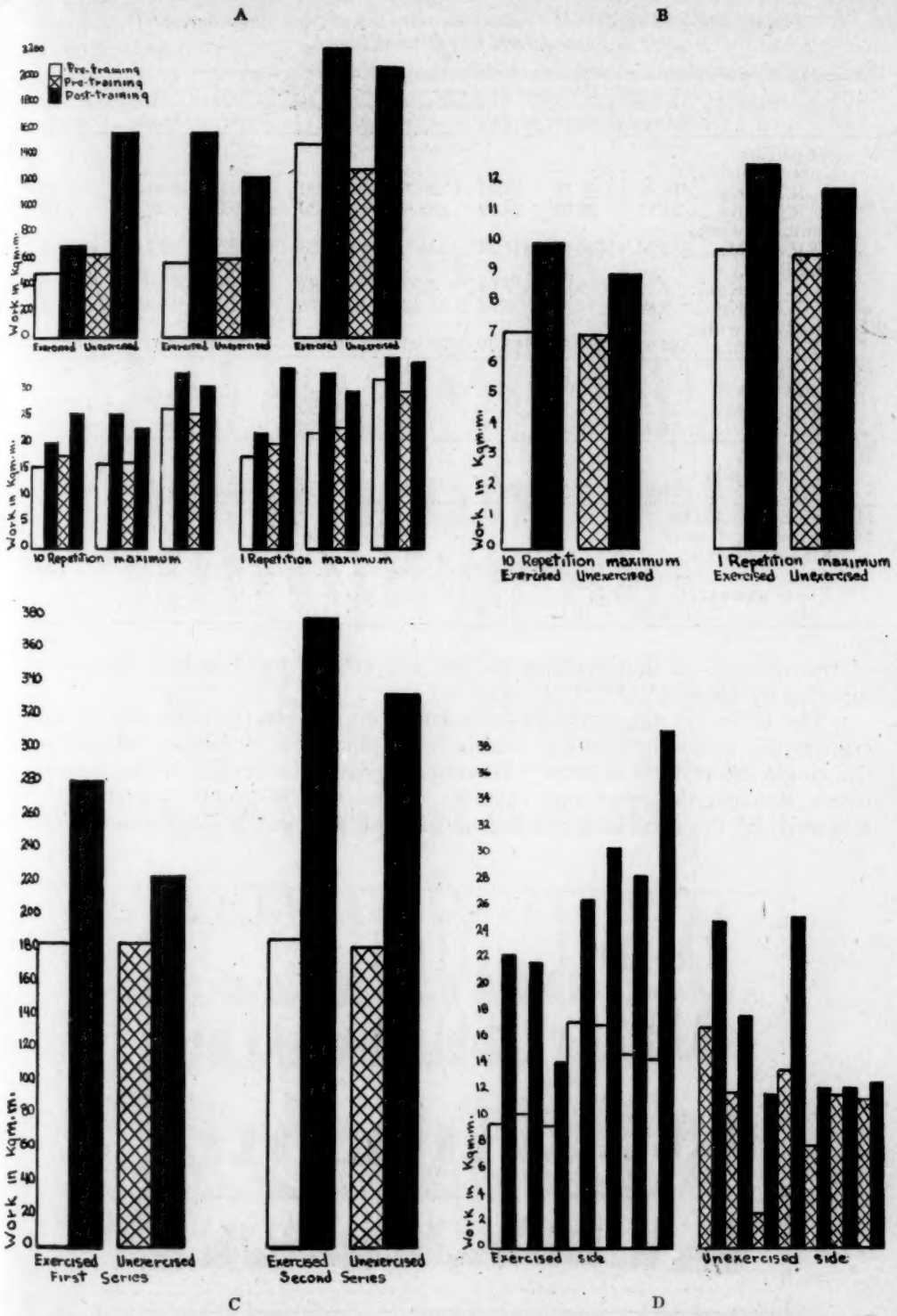

Fig. 1. — *A*, the influence of unilateral heavy resistance exercise of the quadriceps on total limit day work, the 10 R.M. and the 1 R.M. of the practiced and unpracticed side. Observations made on 3 women. *B*, the influence of unilateral heavy resistance exercise of the elbow joint flexors on the 10 R.M. and 1 R.M. of the practiced and unpracticed side. Average of 14 subjects. *C*, the influence of unilateral heavy resistance exersise of the elbow joint flexors on the limit day work of the practiced and unpracticed side. First series: average of 14 subjects. Second series: confirmatory observations on a limited group of subjects who repeated the experiment after layoffs of variable duration. *D*, the influence of unilateral ergographic exercise of the digital flexors on the total work done by the practiced and unpracticed hand in a bout of 20 consecutive "all out" efforts. 6 subjects, 2 series of observations on one.

The Influence of Ipsilateral Training on the Strength and Endurance of the Contralateral Unpracticed Limb.

Type of Exercise	Limb Measured				Difference in Training Effect			
	Exercised		Unexercised		Absolute		Relative	
	Before	After	Before	After	Ex.	Unex.	Ex., %	Unex., %
Weight Lifting,								
Knee extension,								
10 R.M. Kg.....	19.58	26.38	19.95	26.76	+ 6.80	+ 6.81	+34.73	+34.13
1 R.M. Kg.....	24.11	30.91	24.49	33.56	+ 6.80	+ 9.07	+28.20	+37.03
Limit day work,								
Kg. = M.....	852.24	1490.52	841.24	1623.82	+638.28	+782.58	+74.89	+93.03
Hand curl,								
10 R.M. Kg.....	7.13	9.96	7.04	8.99	+ 2.83	+ 1.95	+39.69	+27.70
1 R.M. Kg.....	9.80	12.56	9.64	11.82	+ 2.76	+ 2.18	+28.16	+22.61
Limit day work,								
Kg. = M.....	184.91	281.52	185.59	223.90	+ 96.61	+ 38.30	+52.25	+20.63
Ergograph,								
Total work,								
Kg. = M.....	13.25	26.15	10.90	16.65	+ 12.90	+ 5.75	+97.36	+52.75
Kg. M.	13.25	26.15	10.90	16.65	+ 12.90	+ 5.75	+97.36	+52.75
Dynamometer,								
Grip strength,								
Kg.	29.22	32.56	28.67	29.11	+ 3.34	+ 0.44	+11.43	+ 1.53
Martin's Strength Test,								
Martin's strength test,								
Elbow flexors,								
Kg.	24.04	23.37	24.07	22.88	— 0.67	— 1.19	— 2.79	— 4.94
Elbow extensors,								
Kg.	14.48	16.12	15.98	15.77	+ 1.64	— 0.21	+11.33	— 1.31

of transference of improvement to the unpracticed hand is less than that reported by Davis (1900).[3b]

The effects of practice and cross education, so clearly indicated by the ergographic and weight-lifting criteria, were much less strikingly reflected in the single effort muscle tests. Whereas ergographic flexion of the fingers nearly doubled the functional capacity of the muscle groups exercised, as measured by the total kilogram-meters of work done in 20 consecutive bouts

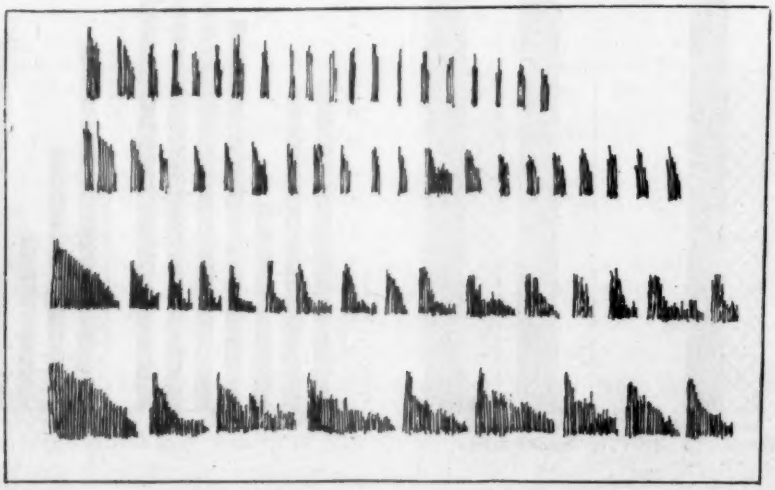

Fig. 2. — Progressive increase of power of the unexercised contralateral left hand. The initial observation was made on May 23, 1946. The second was made on June 13 at the termination of the first series of cross learning experiments, during which the ipsilateral limb (right hand) practiced 12 times in the twenty-two days. The second series commenced on June 28. The third kymogram was made on August 6 after the exercised hand had practiced 26 additional times in a period of thirty-eight days. The terminal observation was made on August 12 without further exercise of the practiced hand. Load lifted and rhythm of exercise were uniform throughout.

of repetitive work, grip strength, as measured by a single effort muscle test, improved only one-tenth as much. The Martin strength test, which is similar in principle to manual muscle testing, failed completely to demonstrate the effects of heavy resistance exercise. There was visible hypertrophy of the biceps brachii, and several subjects reported that uniform sleeves which had

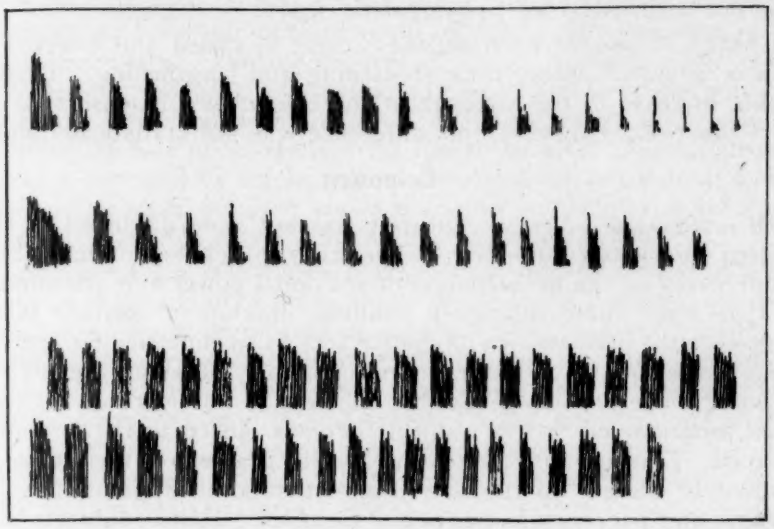

Fig. 3. — Initial kymogram made by the exercised (right) hand on May 21, 1946. Random record made by the same hand on July 30. In the first series of experiments the subject exercised 12 times in twenty-two days; in the second, 18 times in thirty-six days. There was a twenty day rest pause between the two series. Although the height of the contraction increased, the subject made no significant gain in endurance, terminating the effort precipitately with the onset of discomfort.

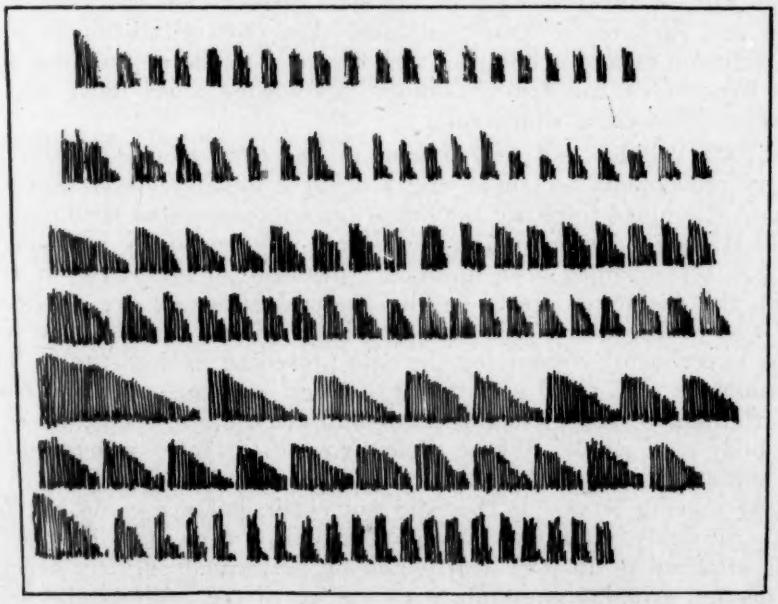

Fig. 4. — Progressive increase in the total work done by the exercised hand (right) of D. W., who carried a comparatively light load. Load and rhythm uniform throughout. The first two observations were made on July 1, 1946, with a half-hour rest between the two series of 20 consecutive "all out" efforts. The second two observations were made on July 18, the fourteenth day of practice. The next two observations illustrate the terminal power of the exercised hand after 29 double periods of practice spread over thirty-nine days. The bottom kymogram illustrates the terminal power of the unpracticed contralateral limb (left hand), which showed negligible cross learning.

previously been loose, were noticably tight before the experiment terminated. Although the maximum load lifted once, the maximum load lifted ten times and the total work done on the limit day rose significantly, Martin's test indicated no increase in the strength of the elbow joint flexors. Single effort muscle tests are influenced notoriously by many uncontrollable variables. Their validity as objective criteria of the functional activity of skeletal muscles has not been subjected to systematic study.

In heavy resistance exercise, the weight is raised and lowered slowly. Tension is produced during both shortening and lengthening. There was a noticeable increase in the strength of the elbow joint extensors as a result of direct practice. However, this difference was not statistically significant.

Comment

The mechanism of cross education has not been discussed in the light of modern physiologic thought. The early psychologic literature placed dominant stress on the development of volitional power and attention, postulating that when these intangible qualities develop in relation to one act they expedite the performance of similar acts by symmetric or closely related anatomic parts and, in a lesser degree, possibly augment the performance of all acts.[3b] There is no doubt that the will to put forth an all out effort develops progressively as the subject becomes inured to the discomforts of the exercise. This has a profound effect on the gradient of the training curve. Unfortunately, there is no known objective method of differentiating between physiologic and psychologic end-points of effort. Hence, subjects unwilling to continue physical work when it ceases to be easy are wholly unsuitable for the study of the physiologic effects of exercise.

Cross education has also been explained in terms of Thorndike's theory of identical elements[8]: that is, the degree of transfer from one task to another is a function of the incidence of identical elements in the two situations. Wissler and Richardson[9] first postulated that cross education is the result of the diffusion of motor impulses which spread to the unpracticed side. Of all the hypotheses, modern physiologic knowledge lends itself best to this interpretation of cross education.

In 1900 Wissler and Richardson[9] made crude studies of the bilateral accessory movements accompanying a discrete unilateral act. Subsequently Freeman[8] attempted to record the tonus patterns associated with motor learning and studied their facilitating influence. All purposive volitional movements are accompanied with automatic postural adjustments. If these are forceful, the resultant effects on the postural substrate are necessarily bilateral and widespread. This was especially evident in the heavy resistance exercise experiments comprising the data presented in this study. The hand curl cannot be performed unilaterally without eliciting extensive compensatory variations in stance designed to equilibrate shifts in the center of gravity of the body as a whole. These occur because of the asymmetry of the exercise and are accentuated by the carrying of very heavy weights at the end of a long moving lever. If they did not occur, balance could not be maintained. Similarly, unilateral knee joint extension carrying a load of 70 or 80 pounds attached to an iron boot, could be performed only by bracing with the arms and gripping the table with the leg of the contralateral side. The unconscious reflex figure accompanying heavy resistance unilateral exercise of the quadriceps was characterized by widespread synergistic cocontractions of many muscles in order to stabilize the posture.

8. Freeman, G. L.: Introduction to Physiological Psychology, New York, The Ronald Press Co., 1934.

9. Wissler, C., and Richardson, W. W.: Diffusion of the Motor Impulse, Psychol. Rev. 1:29-38, 1900.

Early in the cross education experiments, it was observed that powerful isometric tension developed in the symmetric muscles of the unexercised side. When a very heavy load was slowly lifted and lowered by unilateral knee joint extension, 1 subject demonstrated marked postcontraction of the contralateral extremity. The leg seemed to "float" upward. The contraction of the knee joint extensor was involuntary and roughly proportional in magnitude to the force and duration of the sustained effort of the opposite leg. Postcontraction was never seen on the ipsilateral side. If it occurred, movement was suppressed by the heavy weights attached to the limb which hung relaxed and pendent between successive efforts. This is striking evidence of powerful insensible activity in the contralateral quadriceps.

Post contraction is a reflex phenomenon, due to after-discharge or an enduring central excitatory state following powerful contractions, facilitated and reinforced by a reverberating proprioceptive bombardment.[10] After-contractions are very marked in crossed extensor reflexes of the decerebrate preparation.[11] Allen has described unpublished work of Whisler indicating that the phenomenon may be augmented by the simultaneous bilateral isometric contraction of the arms and the contralateral leg.[12] According to Allen, it may be evoked both ipsilaterally and contralaterally and transferred from leg to arm ipsilaterally.

Cross education is obviously a misnomer. The unpracticed limb is not unexercised. It participates in the reflex figure with which powerful unilateral contractions are associated. The tension developed is essentially isometric and hence imperceptible as gross movement. The only subjects in the weight-lifting experiments herein reported who did not demonstrate increase in the strength of the contralateral limb were those who failed to put forth sufficient effort, accepting a psychologic, rather than a physiologic, end-point of exercise. One paradoxic phenomenon occurred. In the ergographic experiments, D. W. made the maximal gain in power observed in any subject on the practiced side. This was, however, unassociated with significant increase in the strength of the contralateral limb. That the load carried by D. W. was comparatively light is evident in the kyograms (fig. 4). It required many more contractions to produce fatigue than that characteristic of the work of the remaining subjects, and D. W. alone demonstrated a plateau before subsidence of contraction. Further to understand this aberrant finding, J. F. H. and S. J. H. repeated several bouts of ergographic exercise carrying 75 to 50 per cent of the load selected for the cross education experiments. That the load initially assigned was greatly in excess of the optimal was clearly evident, for the total work done rose from 16.07 to 35.95 kilogram-meters in one, and from 37.35 to 50.01 kilogram-meters in the other. These findings suggest that the total work done is unimportant, the determining causal factor is so-called cross education being the severity of the effort. When the subject works against very heavy resistance and continues the effort in spite of discomfort, sufficiently widespread irradiation occurs to affect the strength of the unpracticed limb significantly.

In 1923 Walshe[13] made an exhaustive study of the so-called "associated movements" demonstrable in spastic hemiplegic patients and evoked by forceful tonic voluntary contraction of the contralateral side. Walshe con-

10. Forbes, A.; Baird, P. C., and Hopkins, A. McH.: The Involuntary Contraction Following Isometric Contraction of Skeletal Muscle in Man, Am. J. Physiol. 78:81-103 (Sept.) 1926. Zigler. M. J.: The Neurophysiology of Post-Contraction, Psychol. Rev. 51:315-325 (Sept.) 1944. Sapirstein, M. R.; Herman, R. C., and Wallace, G. B.: A Study of After-Contraction, Am. J. Physiol. 119:549-556 (July) 1937.

11. Creed, R. S.; Denny-Brown, D.; Eccles, J. C.; Liddell, E. G. T., and Sherrington, C. S.: Reflex Activity of the Spinal Cord, Oxford, Clarendon Press, 1932.

12. Allen, F.: The Post-Contraction of the Muscles of the Arm, Quart. J. Exper. Physiol. 26:305-317, 1937.

13. Walshe, F. M. R.: On Certain Tonic or Postural Reflexes in Hemiplegia With Special Reference to the So-Called "Associated Movements." Brain 46:1-37 (May) 1923.

cluded that the associated movements of a hemiphlegic person are, in effect, tonic postural reflexes arising in and acting on the limbs. They are aroused only if the voluntary contractions are forceful and of a kind demanding widespread synergic fixation of the musculature. These observations thus lend further indirect support to the hypothesis presented in explanation of the phenomenon of cross education—that is, its dependence upon reflex mechanisms situated in the brain stem which unite the musculature of the extremities into a labile, adaptive postural substrate, upon which cortically controlled movements may be superimposed. In the spastic hemiplegic patient, the postural reflexes of the involved side are free of cortical control and sufficintly exaggerated to cause visible movement of the homolateral appendicular segments.

The phenomenon described in this study has sufficient probable therapeutic utility to warrant consideration. The development of isometric tension through so-called "muscle setting" has long had an accepted place in physical medicine. Where volitional control is defective, powerful isometric contraction may be evoked reflexly.

To our knowledge, the efficacy of "muscle setting" in the preservation of muscle power or its augmentation has never been subjected to quantitative study. There is no a priori reason why it should be superior to increase in tension elicited reflexly, and there are several reasons why it might be less effective. "Muscle setting" is a learned act profoundly influenced by kinesthetic acuity. Its performance probably requires more attention and will power than the execution of exercises which produce visible motion in various anatomic parts. It does not lend itself to readily discernible gradation in dosage or to the setting up of self-testing goals. Thus, graded exercise of the uninvolved extremity may be utilized to evoke proportionate reflex activity of the musculature of the affected side, rendered inaccessible either through mechanical immobilization or through defect in innervation.

Although the study reported was not concerned with motor learning per se, there is much scattered evidence which indicates that the acquisition of skill and precision of motion in one extremity may be augmented without direct practice by subjecting the contralateral limb to training. Thus the physical therapist might expedite the reeducation of unilaterally involved muscle groups by progressive training of the contralateral limb in the execution of symmetric acts describing a mirror image of the movements desired on the ipsilateral side.

Summary and Conclusions

Fifteen normal healthy adult women were subjected to a series of cross education experiments whereby the influence of unilateral exercise of various types might be measured in relation to concurrent changes in the strength and endurance of the contralateral unpracticed limb. The evidence presented substantiates the following conclusions:

1. Unilateral heavy resistance exercise which rapidly augments the strength and staying power of the ipsilateral limb has a strikingly similar concomitant effect on the contralateral unpracticed limb.

2. Improvement in the functional capacity of the symmetric muscle groups of the unexercised side is usually less marked than that resulting from direct practice.

3. The determining casual factor in so-called cross education is the severity of the effort evoking the response rather than the duration of exercise.

4. It is suggested that cross education has a dual genesis in the diffusion of motor impulses to the unpracticed side via irradiation and tonic pos-

tural reflexes arising in and acting on the limbs but modulated by reflex mechanisms situated in the brain stem.

5. Powerful unilateral exercise evokes widespread synergistic cocontractions which take the form of a postural substrate upon which cortically controlled movements are superimposed.

6. Nothing in this study indicates whether or not muscle groups of the contralateral limb symmetric to those exercised on the ipsilateral side exhibit higher degrees of reflex isometric tension than other anatomic parts participating in the adaptive reflex figure.

7. Cross education is a misnomer if it presupposes that the unpracticed limb is unexercised.

8. It is suggested that cross education may serve as a useful therapeutic tool in cases in which volitional control is unilaterally defective, or in which contralateral muscle groups are rendered temporarily inacessible through immobilization.

9. Doubt is thrown on the validity of the single effort muscle test as a criterion of the functional capacity of skeletal muscles.

The finger ergograph used in these experiments was devised and constructed by Prof. L. E. A. Kelso, of the Electrical Engineering Laboratory, College of Engineering, University of Wisconsin.

REHABILITATION OF PATIENTS WITH SPINAL CORD INJURIES *

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HINES, ILL.

This paper is a brief description of the rehabilitation program for patients with spinal cord injuries as instituted at the Veterans Administration Hospital, Hines, Ill.

One of the greatest challenges to the persons engaged in rehabilitation is the problem of the patient with a spinal cord injury. Even though the number of these patients is relatively small in comparison with the total number of disabled either in war or in peace, yet these few require the maximum that any rehabilitation program can offer. These patients are severely disabled and handicapped.

In rehabilitation, the aim is to restore the handicapped to maximum physical, mental, social, vocational and economic adjustment. To attain the fullest life comparable with the patient's abilities and disabilities is the goal. The majority of spinal cord injuries are either due to direct injury to the cord following a penetrating wound or secondary to vertebral fractures resulting in compression or severance of the cord.

The vastness of the rehabilitation program is at once realized. Until the establishment of the present type of program, most patients with spinal cord injuries were considered as hopeless. The success of this program is

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accomplished through a thorough and complete analysis of the problem together with an efficient organization.

The Veterans Administration is carrying on the splendid work initiated by the armed forces in the rehabilitation of patients with spinal cord injuries.

The success of any rehabilitation program depends on the promptness with which the patient participates in the program. The time interval between the onset of the disability and the entry into the program should be a minimum. The rehabilitation program bridges the tremendous gap in the path of the disabled person on the way to attaining his goal. Delay in attaining this goal often results in a state of mental depression together with decreased restoration of function. Return the disabled patient to a full life as quickly as possible.

A tremendous job is in store. It is not and cannot be a one man job. It is a job of such magnitude that one must introduce an array of talent covering every phase that will result in the restoration of the handicapped to fullest usefulness. All activities in the rehabilitation program must aid and motivate the disabled toward rapid recovery and toward the true objective of purposeful living.

A plan must be evolved to rationalize the indicated treatment. The attempt should be carefully planned and be under the most skilled direction. To restore or improve persons who have suffered from disease or injury requires the use of all available measures.

Rehabilitation starts from the very moment that any type of treatment is instituted, even though it may have been the first aid rendered at the time of injury. What is equally important, and not always realized, is that rehabilitation does not end when the patient is discharged from the hospital. Rehabilitation does not end until the handicapped has received maximum benefits in the fullest sense—maximum usefulness. Make the problems of the patient our problems.

Every one has a part to play in the program of rehabilitation. It must not be forgotten that the patient also has an important part to play. Team work is essential. The patient must be made to realize that he also shares in the responsibility of his recovery. "Your recovery depends upon not only on what we do for you, but also on what you do for yourself," should be the motto for the disabled.

Covalt and Covalt[1] have very aptly stated: "Keep busy, enjoy helping yourself get well, and, while you won't exactly find being sick a pleasure, it will have some good points if you make use of your convalescence intelligently."

Successful rehabilitation is accomplished through the closest coordination of all activities and the fullest cooperation of all concerned. At times it is difficult to evaluate maximum recovery. However, the ultimate test is the return to useful work with renewed mental courage, comparable to that existing previous to the disablement. The patient must adjust himself to his new environment and circumstances after leaving the hospital; he must be able to meet the physical demands of daily life.

Deaver and Brown,[2] at the Institute for the Crippled and Disabled, New York, have pioneered in developing procedures and training of personnel in the rehabilitation of the severely disabled. In order to become self reliant and independent, this type of patient must achieve many different skills.

1. Covalt, Donald A., and Covalt, Nila K.: You Can Get Well Faster (pamphlet), Washington, D. C., Whitlock Press, 1945.
2. Deaver, George G., and Brown, Mary E.: Physical Demands of Daily Life: An Objective Scale for Rating the Orthopedically Exceptional, In Studies of Rehabilitation (pamphlet), New York, Institute for the Crippled and Disabled, 1945.

"My Own Score"[3] a Veterans Administration Form, which lists seventy-two various activities, including automobile driving, is kept for each patient, and on it is recorded the date when each activity has been accomplished. This tends to introduce a competitive spirit among the patients, which is an extremely helpful motivating procedure.

What services are included in the rehabilitation program for the patients with spinal cord injuries? This program with some modification is applicable to most any type of disability. Only the general plan of the rehabilitation program will be considered in this paper. In this plan, avoidance in the patient of fear, self pity, resentment and morbid psychologic factors is of prime importance.

The following services participate in the Rehabilitation Program: Neurosurgical, Neurological, Psychiatric, Urological, Orthopedic, Physical Medicine Service (Physical Therapy, Occupational Therapy, Corrective Physical Rehabilitation), Retraining Service (Prevocational Shop Retraining, Educational Retraining, Industrial Therapy), Nursing Service, Dietetic Service, Vocational Rehabilitation Service (Vocational Counseling, Guidance and Training), Special Services (Recreational Athletics, Recreational Activities, Red Cross, Library, Chaplain Service), Social Service and others. The activities of all these services must be closely integrated and coordinated.

The Director of the Rehabilitation Program must be the coordinating member for the effective operation of the various services constituting the program, in close cooperation with the other professional services at the hospital. All the patient's activities must be on a prescription basis approved by the patient's doctor and scheduled for definite periods during the day. Each patient has his own rehabilitation schedule, upon which is indicated the prescribed treatment or activity and the appointment time. All personnel play an important part in establishing and maintaining patient-personnel good will. Getting well must be made attractive to the patient.

The inestimable part played by the neurosurgeons, neurologists, psychiatrists, urologists and orthopedists will not be discussed in this paper. The other services participating in the rehabilitation program will be briefly described.

Nursing

Since the patient with a spinal cord injury must be hospitalized for a long period, the task of the nurse is of unusual importance. It requires a great deal of patience, skill and an abundance of cheerfulness. The nurse must be kind, understanding and properly trained to carry out the multiplicity of orders twenty-four hours a day. Rehabilitation cannot be successfully accomplished without the services of specially trained nurses. Also, it is of extreme importance, that the hospital attendants be specially trained and instructed in the care of this type of patient. Experience has shown that the patients' morale is highest when they are together in large, cheerful wards (fig. 1). They can observe the other patients' progress on the rehabilitation program. They see others who are "making the grade."

Physical Medicine Service

The Physical Medicine Service consists of physical therapy, occupational therapy and corrective physical rehabiliation. Krusen[4] has stated that it is becoming more and more apparent that physical medicine is expanding rapidly and in the future will encompass a broad phase of medical practice. An exhaustive evaluation of the physical condition of the patient must be

3. My Own Score, V. A. Form 10-2555, Washington, D. C., United States Government Printing Office, April 1946.

4. Krusen, Frank H.: The Expanding Field of Physical Medicine: Proc. Staff Meet., Mayo Clinic, 497 (Dec. 26) 1945.

made preparatory to the institution of physical medicine. Motor and sensory involvement, muscle tests, including degree of spasticity and range of motion, must be made. The presence or absence and the state of decubitus ulcers must be noted. The patient's activity level must be determined. The present condition is noted and recorded so that progress can be evaluated. All procedures are carried out by qualified physical therapists.

Fig. 1. — A typical ward for patients with spinal cord injuries

All forms of physical therapy procedures are utilized when indicated and prescribed by the physiatrist. Patients with decubitus ulcers are treated in the Hubbard tanks (fig. 2). There must be a continuous flow of water in the tank during the treatment. After the patient's removal from the tank, the ulcers are dried by means of the ordinary electric hand hair drier (fig. 3). This is followed by local ultraviolet irradiation of the ulcer (fig. 4). The size of the ulcer is measured every ten days, in order to evaluate the treat-

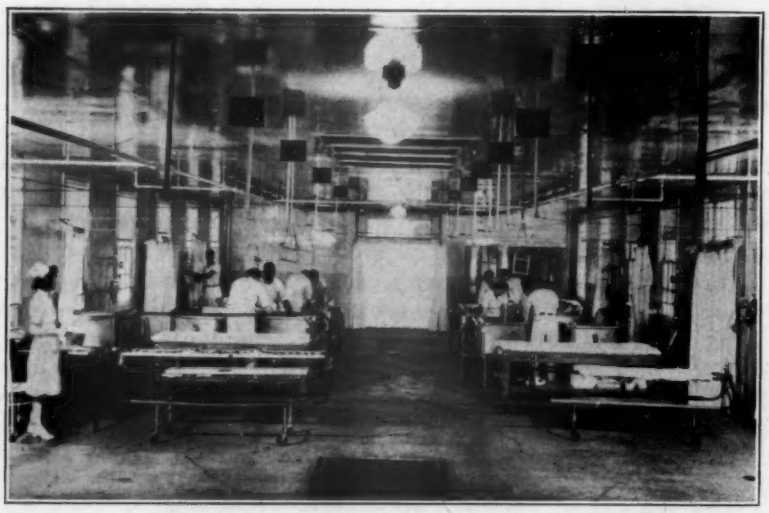

Fig. 2. — Hydrotherapy section

ment. Other methods of treating decubitus ulcers are used, such as penicillin packs, penicillin by ion transfer, various types of ointment, packs and irrigations. However, it should be remembered that the best treatment is in the prevention of the ulcer. Many of the decubitus ulcers must be closed by plastic surgery, which saves many months of treatment and may even save life.

Occupational Therapy

All phases of occupational therapy are taught the patient under the close supervision and guidance of trained occupational therapists. The therapists

Fig. 3. — Drying decubitus ulcer with electric hand hair dryer

provide a progressive, constructive form of therapy toward a definite objective, at the same time building and improving morale. Participation is by the doctor's prescription only.

Corrective Physical Rehabilitation

Corrective physical rehabilitation starts early. Exercise to maintain muscle tone and development, prevent contractures and preserve normal

Fig. 4. — Ultraviolet irradiation of decubitus ulcer.

range of motion, must be instituted as early as possible. Ambulation is the goal and is possible with the aid of crutches and braces for all but a few of the patients with spinal cord injuries. Preparation for crutch-walking can be started while the patient is still confined to bed. Mat exercises are instituted as soon as possible as a preliminary to ambulation. Completely equipped therapeutic exercise rooms are a necessity (fig. 5).

Deaver and Brown[5] have stated that the modern crutch-walker can become efficient on crutches, if he is willing to follow a systematic program with competent instruction, step by step, amassing simple knowledge, using common sense in the application of that knowledge and persisting unrelentingly in regular practice. In fact, it is possible for him to become so much the master of his crutches that they are extra limbs, almost as sensitive and obedient to the will of their owner as if they are actually a part of him.

In learning to balance and in early crutch-walking a special safety harness suspended from a yoke and compression spring, which is attached to an overhead trolley, is used (fig. 6). The harness is fastened around the lower portion of the chest avoiding the axillas. This apparatus does not support the patient but merely prevents him from falling to the floor if he loses his balance. The compression spring takes up the shock of the fall. As soon as the patient learns to balance and begins to walk with his crutches, use of the safety apparatus is discontinued. It is used only for a few days, to help overcome the mental hazard attached to the danger of falling, which

Fig. 5. — Therapeutic exercise room

is an important factor in beginning ambulation. It also helps instill confidence in the patient, resulting in faster progress.

All procedures necessary for daily living, such as walking, bending, turning, climbing stairs and curbs, putting on and removing braces and personal cares, are taught the patient. At first it may take hours to put on his braces; later, as the training progresses, it may only take a fraction of an hour. Successful ambulation is impossible without properly constructed and fitted braces. Braces should be adjusted with the patient in an upright, weight-bearing position. Pressure areas must be entirely eliminated.

The patient with a spinal cord injury may need braces and crutches throughout his life. Just as a hearing aid helps one to hear better, just as an artificial leg helps one walk better so it is with the type of this patient—crutches and braces enable him to walk.

Swimming is an important part of the rehabilitation program. The benefits of underwater exercise in developing weak muscles is well understood. The water in the swimming pool is kept at a temperature of 85 F., the surrounding air being 90 F. The paralyzed lower extremities do not offer as much resistance to movement in the water as they do in walking.

5. Deaver, George G., and Brown, Mary E.: The Challenge of Crutches, Arch. Phys. Med., 397 (July) 1945.

The patients learn to master many swimming strokes without the use of their legs.

When the patient has progressed sufficiently in performing his activities for daily living, he is taught to drive an automobile. Getting in and out of the automobile unaided is part of the task. Automobile driving develops confidence, improves judgment and helps the patient regain skill in approaching normal life. An automobile entirely hand controlled is provided for the driving program. Under instruction, the patient can learn to handle this type of automobile with the skill equal to that of many so-called normal drivers.

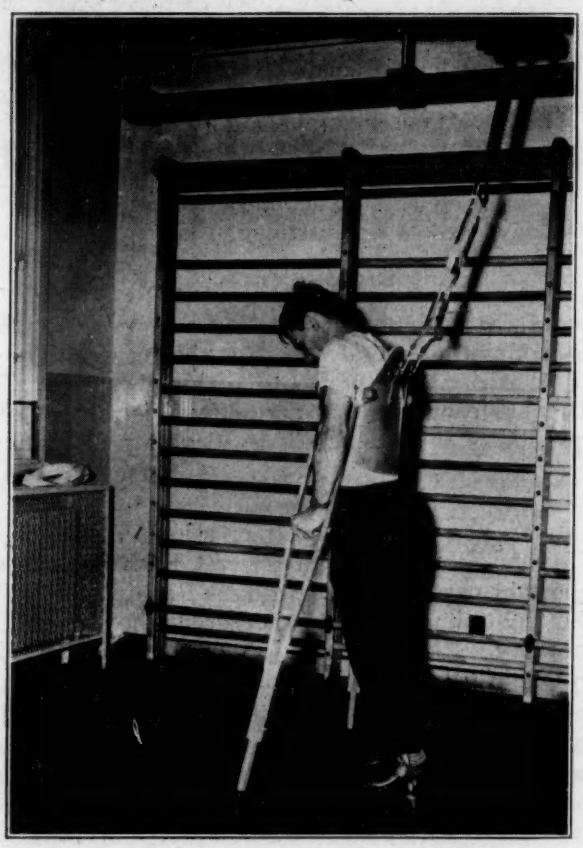

Fig. 6. — Safety harness, showing compression spring and overhead trolley.

Prevocational Shop Retraining

Instruction in prevocational shop retraining should start as early as possible and be primarily purposeful, not time consuming. It should be progressive and continuous toward the goal of "back to a job." The following are offered in the shop retraining program: wood work, watch and clock repair, typewriter and other office equipment repair, plastics, photography, lens grinding, lapidary practice, printing, metal crafts, agronomy, leather craft, floral design and other crafts. The vocational rehabilitation service guides the patient toward the selection of the proper program. Earning a livelihood is necessary for full rehabilitation. A cooperative program with industry to aid further in the program is essential and forms a part of the basic plan of job placement and on-the-job training for the disabled

toward earning a living. Pre-on-the-job training should start in the hospital as part of the rehabilitation program.

Educational Retraining

The educational retraining program also aids in accelerating the patient along the path toward normal activity. It stimulates the mind through education, information and orientation. Courses offered by the Armed Forces Institute, as well as courses from other sources, form a part of the program. The program must be commensurate with the patient's mental and physical capabilities, interest and aptitude. Individual as well as group instruction is given. College as well as high school credits can be secured through this program.

Vocational Rehabilitation Service

Training for special occupations adapted to the particular abilities and disabilities of the patient is playing an ever increasing important role in rehabilitation. Through vocational counseling, guidance and training, patients are aided in selecting suitable employment objectives. Useful, creative employment always makes readjustment easier.

Social Service

Social service assists patients in adjusting themselves to their disability and aids them in formulating sound plans for the future. The worker must understand and deal with all factors, both within the personality of the patient and within his environment, that may effect his rehabilitation. A good social service report is of invaluable aid in planning the patient's program.

Special Services

Under special services are included recreational activities, libraries, the American Red Cross and the Chaplain Service. Each of these services plays a definite and important part in the tremendous Rehabilitation Program. The right book at the right time to the right patient has proved to be an important aid in recovery. The daily services of the trained Red Cross Corps has been of inestimable help to both the hospital staff and the patient.

The work of the Chaplain is primarily that of a pastoral counselor to the patient. There is a need for an understanding and trained listener in the person of the minister. The effectiveness of the rehabilitation program rests upon the adjustment of the patient to life as reflected in his attitudes, his anxieties, his fears, his despair and his hopes.

Summary and Conclusion

1. A brief description of the rehabilitation program for patients with spinal cord injuries as instituted at the Veterans Administration Hospital, Hines, Ill., has been presented in this paper.
2. Rehabilitation of the patient with a spinal cord injury demands the whole-hearted efforts of all personnel, including the patient, together with a well planned, efficient organization. It is not a one man job.
3. The patient with a spinal cord injury who is intelligent and cooperative and has at least the partial use of his upper extremities can usually be made ambulatory with the aid of braces and crutches.
4. Trained personnel, the most modern equipment and an endless reservoir of ingenuity are essential for successful rehabilitation.
5. The personnel engaged in rehabilitation can help lighten the burden of the disabled. Happiness in the work is in helping those who need help.

A smile and a kind word to the patient mean much and are good treatment—treatment that can be given without any special apparatus or equipment.

6. The hopelessness of the patient with a spinal cord injury of World War I has vanished.

7. The magnitude of the task of rehabilitation requires that this work be carried on unceasingly and unhesitatingly until the desired goal has been reached.

8. When happiness, satisfaction and contentment have been brought to those who are disabled, then and only then can it be said that the rehabilitation program has been a success and that the job has been well done.

The discussion on this paper will be published in a later issue of the ARCHIVES.

SOME PROPERTIES OF DENERVATED MUSCLE *

The Relation of Fibrillation to Acetylcholine

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Denervated and innervated skeletal muscle present certain similarities as well as differences in function. Many of the differences formerly thought to be qualitative in nature may turn out on closer scrutiny and better control to be only quantitative. Thus Tower,[1] in her 1935 review, pointed out that the reaction of degeneration is a clinical concept and often in error. When stimulated directly, instead of at the motor point, both denervated and normal muscles show variable but usually equal responses to cathodal and anodal closure. Under such conditions excitability to faradic stimulation is likewise preserved for months in denervated muscle. Similarly the strength-duration curve preserves its form after denervation and merely shifts to the right and upward. Doupe[2] has shown that denervated muscle is cooler than normal muscle and when suitably warmed no longer gives a slow, worm-like contraction to brief shocks but gives instead a brisk twitch. To a usually lowered temperature resulting from the decreased blood flow of constant inaction Doupe[3] has also ascribed the atrophy of the overlying skin and appendages and the stubborn ulcerations, incorrectly called "trophic." The muscle atrophy of denervation has been compared by Reid,[4] in an ingenious experiment, with that of disuse and found to be closely similar though more profound.

The analogy between normal and denervated muscle has been extended to more fundamental aspects, such as the mechanism of activation in each. Since it is generally held that striated muscle is stimulated by the release of acetylcholine at the motor nerve endings, a companion hypothesis is current

* From the Department of Physiology, Harvard Medical School.
* Read at the Twenty-Fourth Annual Session of the American Congress of Physical Medicine, New York, Sept. 6, 1946.

1. Tower, S. S.: The Reaction of Muscle to Denervation, Physiol. Rev. 19:1, 1935.
2. Doupe, J.: The Contractility and Excitability of Denervated Muscle, J. Neurol. & Psychiat. 6:141, 1943.
3. Doupe, J.: Studies in Denervation: B. The Circulation in Denervated Digits, J. Neurol. & Psychiat. 6:97, 1943.
4. Reid, G.: A Comparison of the Effects of Disuse and Denervation Upon Skeletal Muscle, M. J. Austral. 2:165, 1941.

for the stimulation of denervated muscle.[5] Since Langley's day much interest has centered in the fine, disordered, ceaseless play of individual muscle fibers, invisible except in the tongue, which is called fibrillation.[6] The hypothesis of the cause of fibrillation may be stated as follows: Denervated muscle, like other denervated structures, becomes sensitized to its chemical mediator, acetylcholine. It will then respond, by fibrillating, to minute amounts of acetylcholine in the body fluids, too small to excite normal muscle.

The evidence for this view consists of the demonstration that denervated muscle is sensitized and will respond by contracture to acetylcholine. The phenomenon of sensitization had already been established for smooth muscle (both for excitation and for relaxation), lachrymal glands, salivary glands, adrenals, and neurons of the superior cervical ganglion. Cannon and Haimovici[7] extended it to the motor neurons of the spinal cord. The law of denervation was invoked to explain pseudomotor contracture of denervated muscle—various phenomena, designated by the names of Sherrington, Heidenhain, Vulpian, Philipeaux and Rogowicz, the common denominator of which is a contracture of skeletal muscle evoked by stimulation of nearby cholinergic structures, such as vasodilator fibers or ganglion cells.[8] It is believed that acetylcholine diffuses from the nerve endings of these structures and stimulates the denervated muscle to produce a contracture, which can be duplicated easily by intra-arterial injection of the drug.[9] These reactions can be potentiated by concomitant administration of cholinesterase inhibitors: eserine, neostigmine, and mecholyl, the potentiation being proportional to their in vitro inhibition of esterase.[8a] This sensitization, measured by threshold dosage, ranges up to forty to fifty fold in mammallian muscle and up to 100,000 fold in the single fibers of the frog.[10]

Close arterial injection of acetylcholine evokes in denervated muscle two discrete and fundamentally different mechanical responses. These consist of a quick initial contraction, followed when the dosage is higher by the familiar slow contracture. The quick response is truly propagated and coincides with a burst of action potentials similar to those arising from stimulation of the motor nerve. The slow phase of the response, on the contrary, is a nonpropagated shortening and is electrically silent. Even the background activity of spontaneous fibrillation is suppressed, often for ten or fifteen minutes. The contracture is accompanied with inexcitability to further doses of acetylcholine and to direct stimulation, thus closely resembling the state known as fatigue contracture in normal muscle.[11]

Few ideas have been advanced concerning the way in which acetylcholine might act to produce the continuous auto-activity which constitutes fibrillation. Brown[9] supposed that there might be smaller amounts of cholinesterase

5. (*a*) Denny-Brown, D., and Pennybacker, J. B.: Fibrillation and Fasciculation in Voluntary Muscles, Brain **61**:311, 1938. (*b*) Solandt, D. Y.: The Physiology of Denervated Skeletal Muscle, Bull. Minn. Med. Found. **5**:15, 1944.

6. It is clinically and electromyographically distinct from *fasciculation*. The condition is not seen in totally denervated muscle. It consists of motor unit discharges, easily visible as series of involuntary twitches, and occurs typically in progressive muscular atrophy and certain allied states. 5a. The twitches were formerly thought to arise in dying anterior horn cells but are now known to have their origin in the distal axon, probably at the site of its division into the definitive branches of distribution. Forster, F. M., and Alpers, B. J.: Site of Origin of Fasciculations in Voluntary Muscle, Arch. Neurol. & Psychiat. **51**:264, 1944.

7. Cannon, W. B., and Haimovici, H.: The Sensitization of Motoneurons by Partial Denervation, Am. J. Physiol. **126**:731, 1939.

8. (*a*) Brown, G. L.: Transmission at Nerve Endings by Acetylcholine, Physiol. Rev. **17**:48, 1937. (*b*) Rosenblueth, A., and Luco, J. V.: A Study of Denervated Skeletal Mammalian Muscle, Am. J. Physiol. **120**:781, 1937.

9. Brown, G. L.: The Actions of Acetylcholine on Denervated Mammalian and Frog's Muscle, J. Physiol. **89**:438, 1937. Rosenblueth and Luco.8b

10. Buchthal, F., and Kahlson, G.: Effect of Acetylcholine and Adenosine Triphosphate on Denervated muscle, Acta Physiol. Scandinav. **2**:284, 1946. Kuffler, S. W.: Specific Excitability of the End-plate Region in Normal and Denervated Muscle, J. Neurophysiol. **6**:99, 1945.

11. McIntyre, R. R.; King, R. E., and Dunn, A. L.: Electrical Activity of Denervated Mammalian Skeletal Muscle as Influenced by *d*-Tubocurarine, J. Neurophysiol. **8**:297, 1945. Brown.9 Rosenblueth and Luco.8b

in denervated muscle than in normal muscle. In such a case the observed sensitivity would be apparent rather than real, the final effective concentration of acetylcholine being higher merely for lack of cholinesterase to reduce it. Although investigators are not in complete accord, such a postulate seems excluded by direct determinations of the cholinesterase content of denervated muscle, which is either normal or even elevated above that of the normal controls.[12] Also left unexplained by this proposal is the fact that denervated structures exhibit lowered thresholds to many pharmacologic agents besides the specific neurohumor.[13] A desirable theory would include not only cholinergic but also adrenegic sensitization phenomena.

The usual mechanism invoked to explain sensitization is that of permeability. Degeneration of nerve endings is supposed to result in increased permeability of the effector organ, thus allowing it to act in the presence of smaller concentrations of excitant.[14] Such a notion fits well the nonspecific character of sensitization and finds support in the experiments of Lyman,[15] who found greater penetration of radioactive potassium into denervated muscle than in normal controls.

The role of the potassium ion is still uncertain. After denervation, muscle exhibits sensitization to it but to a far less extent than to acetylcholine.[16] Lee,[17] from amphibian studies, found that there was a reciprocal relation between potassium and acetylcholine on muscle irritability. A fall in muscle potassium was correlated with an increased response to acetylcholine and vice versa. He found that denervated muscle contained significantly less potassium than innervated muscle and concluded that this reduction is responsible for the sensitization of denervated muscle to acetylcholine.[18] It should be noted that biochemical determinations on denervated muscle are subject to the limitation that the ratio of interstitial components to muscle is much increased as a result of the extensive atrophy. As controls in such analyses, innervated muscle atrophied from disuse should be employed rather than normal muscle.

At this point it becomes necessary to consider objections to the acetylcholine theory of the causation of muscle fibrillation. What follows will not be construed as applying to the interpretation of pseudomotor contracture, whose production by acetylcholine is well established.

The first objection is provided by the experimental evidence of Dale and associates.[19] They showed that in perfused preparations acetylcholine appears in the venous effluent when normal muscle is stimulated. When denervated muscle is stimulated, not a trace of acetylcholine can be found. Yet direct stimulation is known to increase fibrillation.[20] Moreover, curare and eserine, which deeply modify the action of acetylcholine, have little effect on fibrillation.[21] Eccles concluded from single fiber studies that a simple correlation between acetylcholine sensitivity and fibrillation cannot be established.

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12. Marsay, A., and Nachmansohn, D.: Cholinestérase dans le muscle strié après dégénérescence du nerf moteur, Comp. Rend. Soc. de Biol. **126**:785, 1937. Sawyer, C. H.: Cholinesterases in Degenerating and Regenerating Peripheral Nerves, Am. J. Physiol. **146**:246, 1946.
13. Dale, H. H., and Gasser, H. S.: The Pharmacology of Denervated Mammalian Muscle:I. The Nature of the Substances Producing Contracture. J. Pharmacol. **29**:53, 1936.
14. Cannon, W. B., and Rosenblueth, A.: The Sensitization of a Sympathetic Ganglion by Preganglionic Denervation, Am. J. Physiol. **116**:408, 1936.
15. Lyman, C. P.: Penetration of Radioactive Potassium in Denervated Muscle. Am. J. Physiol. **137**:392, 1942.
16. Magladery, J. W., and Solandt, D. Y.: Relation of Fibrillation to Acetylcholine Sensitivity in Denervated Skeletal Muscle. J. Neurophysiol. **5**:357, 1943.
17. Lee, L. Y.: The Mechanism of Sensitization to Acetylcholine by Denervation, Chinese J. Physiol. **14**:357, 1939.
18. Lee, L. Y.: The Influence of Acetylcholine and Indirect Stimulation on the Sensitization of the Rectus Muscle to Acetylcholine, Chinese J. Physiol. **15**:485, 1940.
19. Dale, H. H.; Feldberg, W., and Vogt, M.: Release of Acetylcholine at Voluntary Motor Nerve Endings, J. Physiol. **86**:353, 1936.
20. Eccles, J. C.: Changes in Muscle Produced by Nerve Degeneration, M. J. Australian **1**:573, 1941.
21. Rosenblueth and Luco.8b Eccles.20

Another objection rests in the fact that fibrillation is unaffected by occlusion of the main arterial supply to the denervated muscle,[22] an observation which I have personally confirmed in acute experiments. Nerve endings being the only known source of acetylcholine in normal muscle,[23] their degeneration requires that it be transported through the blood stream to denervated muscle. In the case of pseudomotor contractures, Bender[24] has shown that this transport can occur. No evidence is available as to where the acetylcholine might come from when the circulation is occluded.

Finally, because of their bearing on the acetylcholine theory of fibrillation, I should like to describe some recent experiments of my own, details of which will appear elsewhere. The purpose of these experiments was to determine whether fibrillation could be suppressed by injecting cholinesterase into the muscle.

Methods

A modified method of injection and of electromyography was devised, for the following reasons: The molecular weights of the various cholinesterases, specific and nonspecific, are not known, since pure preparations have so far not been made. It is likely, however, that they are all large molecule proteins of the order of size of globulins from plasma.[25] It therefore seemed useless to inject them intra-arterially and expect them to traverse the capillary walls separating the blood from tissue fluid and muscle. Moreover, the serum already contains appreciable quantities of esterase.

A 26 gage hypodermic needle was accordingly arranged to serve both as a recording electrode and as a means of injecting esterases and other drugs directly into the tissue fluid surrounding the muscle fibers under study. The other electrode consisted of a 34 gage enameled copper wire with 1 mm. of the tip bared, thrust into the muscle a few millimeters from the first. This procedure insured that injected substances were brought to bear on the muscle from which action potentials were being recorded.

Cats anesthetized with pentobarbital sodium (nembutal), which does not affect fibrillation,[22] were used. In most cases the right anterior thigh muscles were denervated aseptically seventeen to forty days before. In a few instances the gastrocnemius-soleus and hamstrings were used. Suitable controls were established, and various drugs tested as a check on the validity of the method. Records were made from the same muscles, usually the sartorii, of the normal and denervated sides. A third channel recorded the electrocardiogram, for observation of possible side effects. The currents were amplified by a Grass ink-writing oscillograph. Effective dosages were found to be of the same order as those required in close arterial injections. Acetylcholine in doses of 0.05 to 0.5 microgram produced its well known effect of depressing fibrillation; the initial quick burst of action potentials has not been observed, possibly being concealed by the injection artifact.

I am well aware that the ink-writing oscillograph is considered by electromyographers to be an inadequate instrument for recording fibrillation, because of the mechanical limitations of its response; yet I was reluctant to discard it without a trial on account of its convenient recording and the fact that up to six simultaneous channels were available. Under the experimental conditions imposed and with the two species used, cat and rabbit, fibrillation was recorded—not accurately, of course, because of the inertia of the pens, but well enough for the purposes of the experiment. My only suggestion concerning previous failures is that denervated muscle will not fibrillate when it is cool, as it usually is. In these experiments it was necessary to keep the animal's rectal temperature around 37 C. and, in addition, to warm the muscle under study with a lamp.

A total of 21 experiments were done on 5 cats. Two preparations of nonspecific esterase (from serum) were used and one of specific esterase.[26] Doses ranged from 10 to 2,000 units, the final volume injected usually being 0.5 cc. In a few instances the femoral artery and vein were compressed for one minute after the injection. In one case, 1,000 units was injected into the femoral artery. In only a single instance

22. Solandt, D. Y., and Magladery, J. W.: Relation of Atrophy to Fibrillation in Denervated Muscle, Brain 63:255, 1940.
23. Nachmansohn, D., and Machado, A. L.: The Formation of Acetylcholine: A New Enzyme: "Choline Acetylase," J. Neurophysiol. 6:397, 1943. Dale, Feldberg and Vogt.19
24. Bender, M. B.: Contractions in Denervated Muscles Induced by Fright as Evidence of Secretion of a Parasympathetic Hormone, J. M. Sinai Hosp. 5:411, 1938.
25. J. L. Oncley: Personal communication to the author.
26. Two of the cholinesterase preparations were supplied by the Sterling-Winthrop Drug Company. The other was supplied through the kindness of Professor E. J. Cohn.

were fibrillation action potentials depressed following this procedure, and in one other case their activity was augmented. In all other cases there was no change. Observations were continued for at least three minutes in each case.

Results

The results are shown graphically in figures 1 to 7. In figure 1 is illustrated the brief mechanical and short-circuit block produced by 0.5 cc. of Ringer's solution injected into a control denervated muscle; in figure 2, the effect on normal muscle, the electrical activity resulting from light anesthesia. Figure 3 shows the action potentials from single fibrillating muscle fibers. Figure 4 shows the effect of acetylcholine on normal muscle. Thresholds varied from experiment to experiment and with different lots of acetylcholine, but in no case did normal muscle show a threshold as low as that shown by denervated muscle, illustration in figure 5. The action of nicotine on denervated muscle is shown in figure 6; in this experiment the oily alkaloid

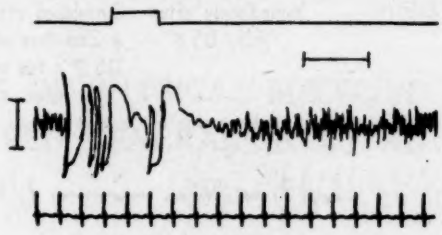

Fig. 1. — Control. Effect of Ringer's solution on denervated muscle. The artefact under the signal was produced by manipulation of the syringe.

Fig. 2. — Control. Effect of Ringer's solution on normal muscle. The artefact under the signal results from manipulation of the syringe.

Fig. 3. — Action potentials from single fibrillating fibers.

was used; the tartrate doubtless would have acted in lower dosage. The action of specific cholinesterase is shown in figure 7. The time calibration in each of these figures is one second; the voltage calibration for the electrocardiogram (lead IV) is 2 millivolts and that for the muscle action potentials is 40 microvolts. When two muscle leads are shown, the upper is always that from the denervated muscle and the lower that from the control normal muscle. Figures 3 and 4 were made with a slightly different technic than that described.

From the data presented—the fact that acetylcholine cannot be recovered in the venous effluent of directly stimulated denervated muscle and that fibrillation is little modified by curare and eserine, by occlusion of the main

vascular supply or by intramuscular injection of cholinesterase—it seems unlikely that acetylcholine can be the inciting agent of fibrillation, however attractive it might be to put the contraction of both normal and denervated muscle on the same basis.

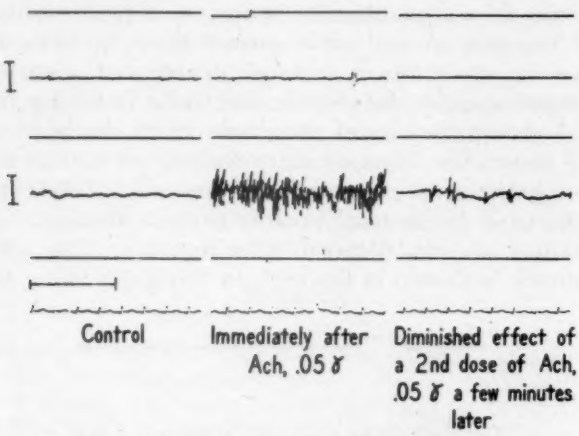

Fig. 4. — Action of acetylcholine on normal muscle

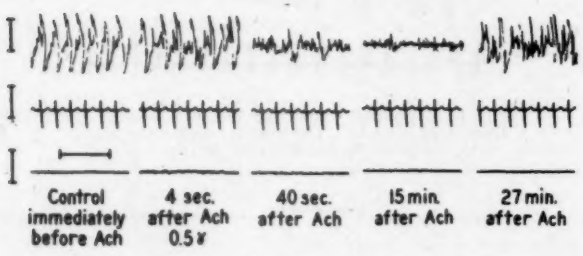

Fig. 5. — Action of acetylcholine on denervated muscle

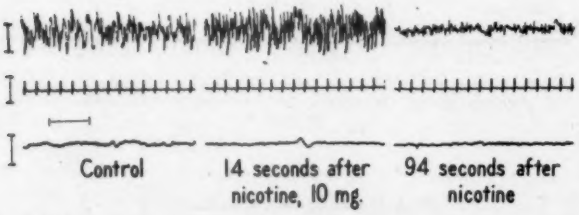

Fig. 6. — Action of nicotine on denervated muscle: first stimulation, then paralysis

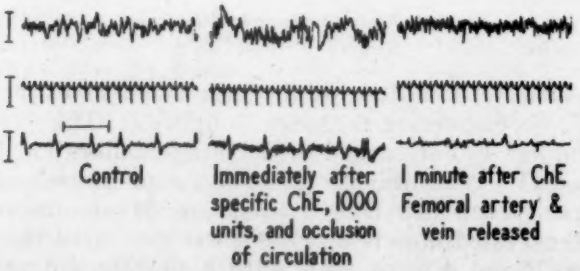
Control
Immediately after specific ChE, 1000 units, and occlusion of circulation
1 minute after ChE Femoral artery & vein released

Fig. 7. — Lack of action of specific cholinesterase on denervated muscle

What alternative can one propose? Tower[1] hinted at a possibility which is in line with the known facts of inhibition as one descends both the neuraxis and the phylogenetic scale, namely, the notion that muscle fibrillates when

freed of nervous control because it is basically irritable to the point of continuous activity.

Summary

Some properties of denervated skeletal muscle have been discussed, with special reference to the role of acetylcholine in fibrillation and in pseudomotor contracture.

Reasons have been advanced for eliminating acetylcholine as an important factor in the genesis of fibrillation.

Among the data in support of this conclusion are included a report on some experiments involving the injection of cholinesterase into the tissue fluid surrounding denervated muscle, with resultant failure to influence fibrillation.

A modification of electromyography, made necessary by the conditions of the experiment, has been described.

HIGH LIGHTS OF PHYSICAL MEDICINE AT WALTER REED GENERAL HOSPITAL

1941 - 1946 *

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1941 to 1946 — these are the years which have witnessed the temporary exodus of many millions of young men and women from their homes, peacetime professions and occupations. These are the years which have seen several hundreds of thousands of these same persons return home afflicted with those disabilities which shadow modern warfare. These are indeed the years which have marched across the page of history. From this terrible textbook what lessons can we seriously say that we have learned, lessons which may be turned to useful account in the solution of peacetime problems in physical medicine? It is with the latter thought in mind that the present discussion has been attempted.

In preface to these remarks, it is to be understood that the practice of physical medicine at Walter Reed General Hospital is no different from that at any other hospital, civilian or military. Further, in the time allotted to this presentation, it is impossible to present a complete exposition of any phase of physical medicine; hence, this paper very literally touches the high points only. Despite the obvious overambitiousness of this attempt to portray the trend of events over a five year period, it is believed that certain of these experiences should be recorded for the interest of those practicing physical medicine.

The activities of the Department of Physical Therapy have revolved about three main considerations:

1. The Training School for Physical Therapists. Very early in the course of the emergency it was foreseen that the demand for trained physical

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* Read at the Eastern Sectional Meeting, American Congress of Physical Medicine, Washington, D. C., April 13, 1946.

therapists would far exceed the number available in the event of hostilities and that the peacetime training course would have to be accelerated. In July, 1941, with the approval of the Council on Medical Education and Hospitals of the American Medical Association, the first of these Emergency Courses was instituted. A complete course consisted of six months of academic training (termed the "Student Period") followed by six months of clinical training under supervision (termed the "Apprentice Period"). Later, in October, 1944, the apprentice period was reduced to three months. New student classes were enrolled quarterly; hence at all times there were present at least three groups of students, each in a different phase of training. During the time these emergency courses were in operation, 256 students were enrolled and 229 students were graduated from the institution. The problem of providing a high standard of academic instruction while meeting the continuously mounting pressure of clinical work with a staff always too few in number and constantly subject to change, was one which, in my opinion, was never satisfactorily solved.

2. Administrative Organization. For many years a specially trained Medical Corps officer has been in charge of physical therapy at this hospital. It is understood that such an arrangement was unique in military establishments during peacetime, assignment to the physical therapy section ordinarily being a part time duty. Within recent years, as we all know, practically all general hospitals have had the services of a physician trained in physical medicine. Professional recognition of such training, however, was not forthcoming until late in 1943, at which time the Military Occupational Specialty 3180 was established.[1] This provided, in part, that such a medical officer "prescribes treatments, develops therapeutic technics, and directs training programs." Unfortunately, such a step was, to a certain extent, nullified by the fact that in mid 1944, by War Department Directive,[2] physical therapy activities were relegated to the Orthopedic Section of the Surgical Service. One consequence of this ruling has been reflected in the difficulties under which any type of investigative work in physical medicine has been carried forward. This is not an excuse, for the demands to "stop messing around with my patients" remain too green in my memory. This unwillingness to share the professional care of patients whose disabilities require physical therapy with physicians specializing in physical medicine remains a problem the solution of which has not yet been accomplished.

3. Professional Considerations. We all remember full well that 1941 and 1942 were not years of peace, yet the tenor of events, so far as physical medicine was concerned at this hospital, remained much the same as during peacetime days. It was not until the last of 1942 that casualties began to flow in, principally from the North African Theater of Operations. Subsequent to this time, there has been a steady influx of casualties. The table presents the patient-treatment load during these critical years. Since a high percentage of all types of combat injuries demand definitive treatment by physical measures, the work increased in roughly the same proportion as did the total patient load in the hospital. From the peacetime general hospital organization wherein the professional staff managed any and all disabilities, our hospital became first a specialty center for practically all types of combat injuries and then, as other specialty centers were established, was stabilized as a center primarily for the treatment of amputations and thoracic, neurologic and orthopedic injuries. The patient load in the physical therapy department was, for this reason, disproportionately heavy

1. War Department Technical Manual TM 12-406, Officer Classification Commissioned and Warrant, Oct. 30, 1943.
2. War Department Circular 281, Section VIII, July 6, 1944.

for these four major disabilities. Very briefly the use of physical medicine in each of these fields will be discussed.

Thoracic Injuries

With the exception of tuberculous patients (who are sent to another center), patients with all types of traumatic and inflammatory conditions involving the lungs and parietes have been seen at this hospital. Despite the diversity of such conditions, their effects, so far as we were concerned, were

TABULATION OF PATIENT-TREATMENT COUNT.

Month	Daily Average Number of Patients *					Number of Treatments				
	1941	1942	1943	1944	1945	1941	1942	1943	1944	1945
January	197	182	266	436	464	8,815	8,655	10,658	22,315	16,377
February	170	212	330	474	318	6,729	8,563	11,720	23,215	17,649
March	166	196	395	471	567	5,914	9,127	12,543	22,862	21,854
April	170	194	322	426	605	6,849	9,045	11,961	21,031	17,543
May	156	194	307	427	669	6,563	8,640	14,231	21,592	21,609
June	170	195	389	420	609	6,913	8,892	14,241	20,029	24,906
July	144	187	377	306	587	6,859	8,530	18,117	15,748	19,961
August	177	183	424	511	485	6,746	8,291	18,167	17,903	20,271
September	179	197	423	425	448	6,995	8,258	17,092	17,408	15,909
October	171	211	392	432	569	8,348	9,646	20,519	18,478	16,696
November	188	213	483	495	444	7,036	8,918	22,752	21,212	13,649
December	169	243	420	396	384	7,952	9,798	19,822	18,144	10,378
TOTAL	2,057	2,407	4,528	5,219	6,122	85,719	106,363	191,823	239,937	216,762

* Based on seven day week thirty day month basis.

surprisingly similar. Two main physiologic defects were seen: deformities of the thorax secondary to postural defects, and functional defects in breathing associated with lowered vital capacity. The basis of both types of defect must be thoroughly understood before the proper type of physical therapy may be prescribed. However, this does not mean that each case must be extensively studied before any exercises are begun, for it is axiomatic that the earlier such exercises are instituted the less the disturbance of structure and function and the more rapid the recovery.

During the early years of the war, many patients referred for treatment of thoracic injury presented the classic picture of the "fused chest." The head was moved laterally toward the injured side; the shoulder of that side was dropped downward; an S-shaped scoliosis developed with the thoracic concavity toward the affected side; the ribs were crowded together on that side and, in addition, were specially depressed over any loculated effusion; there was marked muscular atrophy and weakness with limitation of motion of the shoulder girdle of the affected side; asymmetric respiratory movements were the rule. Severe secondary side effects commonly were a part of this picture: marked general muscular debility incident to the prolonged bed status, severe secondary anemia, loss of appetite and lowered morale and outlook on life in general. Many of these young men looked cachetic. Weight losses of 50 to 75 pounds were not at all uncommon. As Harken[3] has pointed out, the significance of the "fused chest" extends beyond the deformity; the lung underlying the "fused chest" is known to be virtually afunctional and is prone to be involved in all manner of suppurative processes. This is the syndrome which in former years produced the pulmonary cripple.

3. Harken, D. E.: A Review of the Activities of the Thoracic Center for the III and IV Hospital Groups, 160th General Hospital European Theater of Operations, June 10, 1944 to Jan. 1, 1945, J. Thor. Surg. 15:31 (Feb.) 1946.

As the war progressed, such cases were encountered with decreasing frequency. This improved status resulted from several factors, among which may be mentioned the operation of chest surgery teams far forward in the combat zone, the establishment of chest centers within the theater of operations and the high priority of evacuation of such patients from the communications zone. Of equal importance, at least within its own sphere, was the recognition of the importance of the institution of early physical therapy in such cases. This regimen, centering about the use of postural and breathing exercises, has restored the vast majority of patients with chest injuries to something approaching the preinjury physical status.

In the treatment of these chest disabilities, it is interesting to note that the primary injury itself is not the important thing. It is believed that the initial cause of the postural and respiratory abnormalities centers about the reflex changes incident to involvement of the pleurae. Injury to or inflammation of the pleura results in such severe pain that the mechanics of breathing are disturbed and the affected side is voluntarily splinted in a contracted position in order to avoid any but the most minimal movements of the hemithorax and the lung beneath it. This pleural pain probably lasts but a few days; the persistence of the postural deformity is believed to be due to the persistence of the subconsciously formed habits of splinting the chest and breathing abnormally. The ease with which these abnormalities can be corrected by physical therapeutic measures alone seems to me to be the best proof that this assumption is correct.

A detailed discussion of the means by which these disabilities are corrected is beyond the scope of this paper. Excellent descriptions[4] of these treatment programs are available in the literature. The general outline of treatment may be summarized somewhat as follows:

1. The patient, with rare exceptions, never understands anything other than that he will get well. We believe, with the thoracic surgeons, that the patient should expect to be cured. This is not a "pollyanna" attitude, for the pervasion of this confident attitude throughout the ward is considered the initial step toward recovery and is one which will help maintain the patient in the hours of doubt which universally arise. This involves not only a general optimistic spirit but also a careful, frank discussion with the patient of the treatment program and his role in it.

2. The exercises must be instituted early. Whenever and wherever possible these exercises are taught and practiced preoperatively. The presence of drainage tubes, moderate temperature elevations, pain, muscular weakness and dyspnea do not, as a rule, constitute any bar to the institution of these exercises. I have never noted aggravation of the presenting symptoms by the exercise program, primarily because it can always be graded to the tolerance of the patient. On the contrary, the rapid improvement in symptoms and in the increase in appetite, weight, ambulation and strength of the patient add to my conviction of the usefulness of the exercises. Surgical intervention itself interrupts the exercise program by less than two days. On the day following operation the exercises are resumed, gently at first but rapidly increased in scope and duration; habit patterns of muscular splinting and voluntary inhibition of normal breathing habits have no chance to form in this program. These exercises are of two general categories:

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4. Harken, D. E.: A Review of the Activities of the Thoracic Center for the III and IV Hospital Groups, 160th General Hospital European Theater of Operations, June 10, 1944 to Jan. 1, 1945, J. Thor. Surg. 15:31 (Feb.) 1946. Hayward, J. I.: Physiotherapy in Chest Surgery, Australian & New Zealand J. Surg. 13:245 (April) 1944. Huddleston, O. L.; Winston, R., and Engelland, M.: Physical Therapy Procedures Used in the Preoperative and Postoperative Care of Chest Surgery Patients, Physiotherapy Rev. 25:203, 1945.

a. Breathing Exercises. Included here are:

(1). Exercises in abdominal breathing. These are primarily diaphragmatic exercises; hence they are concerned more especially with pulmonary ventilation. However, they serve also to reestablish the normal reciprocal relationship between the movements of the diaphragm and the anterior abdominal musculature.

(2). Costal breathing exercises. Special emphasis is placed on expiration, maximum exchange of tidal air being sought for. In addition, maximum expansion of the involved side is sought for and achieved by concentration on its movement, even at the expense of voluntary splinting or restriction of the movements of the normal side.

(3). Focal breathing exercises. A disproportionate amount of attention must be concentrated on the sunken segments of the injured hemithorax. The English believe that lungs can be selectively reexpanded by these focal exercises; others take little cognizance of them except as a part of the general exercise program. This is probably an unimportant point over which to argue, since general agreement exists as to the same necessity for concentration of exercise effort to these chest segments as there would be for an intensive exercise program for any other part long disused.

b. Postural Exercises. These run the entire gamut from proper bed posture to heavy resistance exercises for the selective redevelopment of certain muscular groups of the affected shoulder girdle. The exercises prescribed, of course, keep pace with the condition of the patient.

The aim of these exercises is not merely the correction of the existing defects, but the repetition of these correct voluntary movments so often that they become involuntary good habits. Only then may one speak of having assisted in the cure of the patient.

Peripheral Nerve Injuries

It is officially recognized[5] that injuries to elements of nervous system constitute one of the most frequent of military injuries. Primary nerve injuries are said to constitute approximately 5 per cent of the total of combat injuries; approximately 15 per cent of all casualties evacuated to the Zone of the Interior have complicating nerve injuries. The management of these conditions during these wartime years received the greatest stimulus by way of measures which attempt to supply information concerning that long period of clinical silence during which neurotization is presumably taking place.

Until recent years, the only diagnostic measurements available for assessment of dysfunction in peripheral nerve injuries have been sensory tests, motor tests and the faradic-galvanic test. Only the latter has been regarded as a truly objective test. Its limitations were numerous. It supplied some information, but it, also, remained silent during much of the neurotization period.

In 1943 instrumentation was provided whereby measurements of alterations in the electrical conductivity of the skin could be utilized as an objective measure of "sensory" changes.[6] This simple test depends on the well known observation that areas of cutaneous anesthesia do not sweat because of the interruption of the postganglionic sympathetic sudorific fibers carried in the trunk of the motor nerve injured. The absence of perspiration, with its contained electrolytes, results in a high skin impedance to the passage of a minute constant current. If the part being tested is otherwise actively sweating, the affected dermatome may be delineated quickly by moving the testing electrode over the skin surface. Transfer of the boundaries of the involved region to a sketch provided a means of recording the skin resistance

5. War Department Circular 73, Section X, March 13, 1946.
6. Richter, C. P., and Katz, D. T.: Peripheral Nerve Injuries Determined by the Electrical Skin Resistance Method: I. Ulnar Nerve, J. A. M. A. 122:648 (July 3) 1943.

pattern. If it is fair to assume that the motor and sympathetic fibers were interrupted at the same point, then improvement in the sympathetic dermatome as gaged by changes in skin resistance would provide reasonable basis for assuming neurotization distal to the site of injury. Additional experience has confirmed the apparent validity of these assumptions. There are several minor objections which have militated against the adoption of the test as a "routine" one: A carefully done test is a somewhat tedious and time-consuming procedure; it must be done under fairly standard conditions if a consistent pattern is to be developed; during regeneration the edges of the dermatome are less sharply defined; the test remains an indirect measure only of sympathetic function, and, finally, the exactness of the test, so far as records preservation is concerned, is a measure of the artistic or draftsmanship abilities of the examiner, who must accurately transfer the pattern to a standardized figure.

Accordingly, when the opportunity developed in 1944 to utilize the quinizarin dye test,[7] it was believed that this test would supply the same information as the skin resistance test and yet would share none of its defects. As with many other similar hopes, this one has not been realized completely. I do believe that this dye provides a more accurate index of function of the sympathetic nervous system than does measurement of the skin resistance by the instrument available; at least one can see the changes produced in the dye by sweating versus nonsweating skin regions. By observing the onset, amount and type of sweating, additional information regarding the functional status of the sympathetic fibers may be obtained over that noted by merely observing the totally developed sweat pattern. There is the tremendous advantage of ease of photographic recording of the sweat pattern; hence, if the necessary precautions are taken, one record is as comparable with the next as are, for example, two electrocardiograms. Changes in quinizarin patterns are, therefore, measurable with some quantitation. However, the thermoregulatory mechanism of the body must be completely activated in order to develop the total sweat pattern. This can most satisfactorily be accomplished by reflex sweating induced by the electric cabinet bath; pilocarpine, acetylsalicylic acid and hot tea and various heat lamps do not, in my experience, produce trustworthy sweat patterns. Further, vascular reflexes, preexisting trophic skin changes, scars, skin grafts and primary sympathetic nervous system defects may modify the picture produced. These do not invalidate the test by any means, but in the interpretation of the sweat dermatome they must be kept in mind.

The most recent and thus far most promising of these objective diagnostic tests in peripheral nerve injuries are the electrodiagnostic tests performed with the Golseth-Fizzel constant impulse stimulator.[8] This precision instrument is valuable, not necessarily because of the "new" information it supplies, but because it provides a group of data of such order of accuracy that some interpretation of the electrofunctional status of the neuromuscular mechanism is permissible, and, further, that one test is comparable with another performed on the same subject at a different time. This instrument delivers a square wave impulse of calibrated duration, the strength of which can be accurately controlled and measured; such impulses can be delivered at known intervals by an electronic switch. No other instrument known to be available supplies the data possible through the use of this stimulator. The primary data obtained with this instrument are as follows:

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7. Rose, D. L.: Colorimetric Demonstration of Sweat Pattern Changes in Peripheral Nerve Injuries, Arch. Phys. Therapy 25:610 (Oct.) 1944.
8. Pollock, L. J.; Golseth, J. G., and Arieff, A. J.: Use of Discontinuity of Strength Duration Curves in Muscle in Diagnosis of Peripheral Nerve Injuries, Surg., Gynec. & Obst. 79:133 (Aug.) 1944.

A strength-duration curve is constructed from which the rheobase, the shape of the curve and usually the chronaxie of the muscle being tested are determinable; the response of the muscle to repetitive stimuli of the order of 500, 166 and 77 stimuli per second is determined; and finally the cathodal and anodal galvanic tetanus ratios are determined. The term "galvanic tetanus ratio," introduced by Mayfield and his associates,[9] refers to the amount of current necessary to sustain the muscle segment in complete tetanus during the flow of current as compared with the amount necessary to elicit a minimal contraction; the terms "cathodal" and "anodal," of course, refer to the polarity of the stimulating electrode. From these determinations valuable information may be obtained relating to neurotization of the nerve fiber and maturation of the axon and motor end plate complex. Changes in the strength-duration curve and the galvanic tetanus ratio are believed to be related to neurotization; response to repetitive stimuli and changes in chronaxie are believed to be related to maturation. All of these results must be interpreted in proper relation to the time interval since injury or surgical treatment.

The delicacy of the instrument at times leads to confusion in interpretation of the results of the tests. It is quite capable of detecting the presence of nerve fibers which are either too few or too immature to be capable of functional restoration of the muscle; it will as easily pick up evidence of rambling fibers which somehow have bridged or grown around a gap in a nerve which is not capable of regeneration. Further, in my experience, it is more difficult to test larger muscles, particularly those of the lower extremity. However, these shortcomings by no means overshadow the value otherwise of the test. It should also be noted that the determination of what today appears to be the most valuable information supplied by the instrument, the galvanic tetanus ratio, can be determined by any instrument which has an accurate milliammeter.

Amputations

The role of physical therapy in the treatment of amputations has undergone several modifications in the past few years. Since peacetime, elective amputations are not the same as amputations which result from combat injuries; peacetime physical therapy practices are not generally applicable to the latter type of amputee. In this discussion only several features of the present day physical therapy treatment will be presented, since all phases of such treatment have by now become extensive. Stages 2 and 3 refer to the lower extremity amputee only.

1. *Management of the Open Amputation Stump Prior to Surgical Revision* — Amputations are received in the Zone of the Interior hospitals as simple guillotine amputations, the site being as far distal in the extremity as possible. The former practice was to place such limbs in traction where they remained until healed; surgical revision of the stump could then be accomplished. Within the past two years, the successful use of two physical therapy procedures has resulted in the referral of these patients with unhealed stumps to our clinic. These procedures are the whirlpool bath and zinc peroxide ion transfer.

(*a*) The Whirlpool Bath. At times, because of the number of patients with amputation wounds sent to us, practically all of our twenty-eight leg whirlpool baths were reserved for these septic patients. Early in the use of this treatment repeated bacteriologic studies were run on the water before, during and after the treatment to determine the possibility of cross

9. Mayfield, F. H.; Oester, Y. T., and Dillon, E.: Electrodiagnosis. Examination of Peripheral Nerve Lesions by Percutaneous Stimulation of Muscle. Instruction Manual for Training Course in Electro-Diagnosis Authorized by the Office of The Surgeon General, Oct. 17, 1945.

infection from one patient to another. When these studies indicated an apparent lack of danger in such use and when simple precautions were used, we proceeded to employ this procedure without hesitancy. For those who look askance at the propriety of immersing an open lesion in nonsterile water, it can only be stated that many thousands of such treatments have been given without evidence of cross infection or aggravation of existing infection. The ready acceptance of this procedure by the patient, the striking relief from pain afforded in many instances and the rapid conversion of a "dirty" lesion into a cleaner, more healthy-appearing one in our experience more than justifies its use.

(*b*) Zinc Peroxide Ion Transfer. Of all the agencies referred to as "healing stimulants," in this clinic the one which is most nearly universally applicable is the procedure of zinc peroxide ion transfer. The impelling of the zinc ion into these unhealed lesions by means of low milliamperege electrophoresis appears to stimulate epithelization powerfully. It is to be emphasized that the current density must be kept low; 3 to 4 milliamperes of constant current for twenty to thirty minutes is far more satisfactory than a higher current dosage. This procedure is not applicable to all unhealed wounds. Not infrequently are seen those superficial, crusted, weeping lesions adjacent to the unhealed stump which are usually diagnosed simply as infectious eczematoid dermatitis. Local irradiation of these regions with ultraviolet rays in combination with a photosensitive dye, such as tincture of metaphen, is helpful, but usually general body irradiation is required to effect complete drying and healing of the local lesion.

(*c*) Bandaging. In this, the unhealed stage, I believe that any bandaging of the stump should be minimal and should attempt only to support the tissue of the stump. Specifically there should be no attempt to shrink or shape the stump. Not only is it impossible to shrink the stump at this time, but any attempt in this direction serves to restrict circulation and to delay healing.

2. *Management of the Patient After Surgical Revision of the Stump.* — (*a*) The primary emphasis in this stage is on the seeking out and correction of abnormalities in body mechanics.[10] This involves: (1) postural tests, (2) tests for flexibility and contractures, (3) muscle tests, (4) specific therapeutic exercises or procedures designed to correct specific abnormalities.

It is obvious from this brief outline that this portion of the treatment program is an individualized procedure. I believe that this individualization is essential if the abnormalities exhibited by a patient are to be corrected before he begins to wear the prosthesis.

(*b*) During this stage, the stump is bandaged with an Ace type bandage in order to shrink and shape it properly for comfortable and efficient fit into the bucket of the prosthesis. It should be noted that the evils attendant on the improper bandaging of the stump potentially outweigh the benefits achieved by proper bandaging. For this reason, great care and skill are necessary for the application of the bandage. If the bandage is applied properly and is reapplied several times daily, freshly laundered bandages being employed with each such application, it is possible selectively to shrink and shape the stump very rapidly. Despite the advice usually given that patients should be taught to bandage their own stumps, it is my impression that proper bandaging is seldom achieved thereby. Bandaging must be done by a person skilled in this procedure.

3. *Management of the Patient After Acquisition of the Prosthesis.* — The aim of education in the use of the prosthesis is to enable the patient to walk

10. Kendell, H. O., and Kendell, F. P.: Care During the Recovery Period in Paralytic Poliomyelitis, Public Health Bull. No. 242, April, 1938.

naturally or normally. The type of amputation the patient has determines to a large extent the amount of attention which must be devoted to teaching him to walk. Persons with below knee amputations seldom require any extensive walking instruction. Those with above knee amputations require considerable training, but the vast majority of them, if existing defects in body mechanics can be corrected, can walk with a gait very little different from that of the normal person. The person with a hip disarticulation or a very short thigh stump which has been fitted with a tilting table prosthesis can never walk as well as a normal person, but he can be taught to walk with an inconspicuous gait. Even patients with bilateral hip disarticulations can be taught to walk.

At the risk of over-repetition, it is again to be emphasized that the prelude to successful walking is the correction of existing contractures and abnormalities in body mechanics before the patient begins to wear his prosthesis. If this can be accomplished, the way is paved for him to become a successful walker; if it is not accomplished, his walking achievements will universally be less than the desired goal.

On the assumption that the prosthesis has been fitted correctly, that the condition of the stump is satisfactory, that the posture muscles are in correct balance and that the subject desires to walk, learning to walk with the prosthesis involves constant drilling on certain fundamentals:

1. Balance. This involves much more than merely being able to perch on the prosthesis without falling down. It includes all the phases of postural balance, from being able to distribute the body weight normally to the legs to being able to know precisely where the prosthetic foot is and to control it during all phases of walking—in other words, the development of a new set of proprioceptive patterns to replace those missing by reason of the amputated extremity.

2. Equal length steps. It is a common observation that the so-called "natural" tendency for the thigh amputee is to take a longer step with the prosthesis than that taken with the normal leg. Contrary to the impression all too prevalent among physicians and patients alike, this asymmetric gait need not exist. In a high percentage of cases it is due to a state of contracture of the hip flexor muscles of the amputated side. In a higher percentage of cases it is simply a poor walking habit. In either event, it is usually correctable.

3. Walking speed. As rapidly as possible, the patient should speed up his walking gait to approximate that of the normal person. The slower the gait, the more conscious effort enters into walking and the longer it takes to drop the walking habits down to the automatic subconscious level.

While the foregoing statements obviously oversimplify the problems encountered in the physical therapy management of the amputee, it is believed that they roughly outline the total situation.

Orthopedic Injuries

It is desired to comment briefly on two procedures employed in the treatment of orthopedic conditions, the use of procaine ion transfer in the treatment of painful muscular and musculofascial conditions and the use of high resistance exercises in the selective redevelopment of certain muscles or muscle groups.

The electrophoretic introduction of procaine into the skin has been reported[11] to be of value in the treatment of pain and muscle spasm. Pain due to a host of alleged causes (bursitis, myositis, fascitis, sprains, strains, etc.)

11. Snow, W. B., and Kraus, H.: Novocaine Iontophoresis for Painful Limitation of Motion, Mil. Surgeon 95:360 (Nov.) 1944.

constitutes one of the major reasons for seeking treatment in the service. It is common experience that no single physical agency has been uniformly applicable and successful in the treatment of such conditions. The procedure of procaine ion transfer is no exception to this rule. However, its use has been so successful in instances clinically diagnosed as acute bursitis, myositis, mild to moderate sprains and strains and lumbago that additional experience may well lead to the conclusion that it is the procedure of choice in the treatment of such conditions. My colleagues and I have made a minor deviation in the original formula described by Snow and Kraus[11] in that the vehicle employed is 95 per cent ethyl alcohol rather than the 80 per cent solution described by these authors. The greater alcohol strength definitely produces a deeper, longer lasting surface anesthesia than that which results when the weaker solution is employed.

The high resistance exercises, which depend on the old physiologic principle of progressive loading of a muscle, have been used empirically for many years by weight lifters and "strong men." DeLorme[12] appears to have been the first to utilize these methods systematically in therapeutic exercise. By means of these high resistance—low repetition exercises, muscular power may be developed rapidly in the presence of an intact neuromuscular mechanism. In the present stage of their development, these exercises are most successfully adapted to quadriceps exercise. Hypertrophy of this muscle group can be accomplished with amazing rapidity. This is specially desired in injuries of the lower extremity, particularly those involving the knee joint. The all too common persistence of disability following surgical removal of a fractured knee cartilage, despite earnest attention to static contractions of the quadriceps and other measures believed to be beneficial, is well known. In contrast, the functional stability of the knee in a patient who has faithfully carried out the high resistance exercise program has completely changed a guarded prognosis as to the ultimate value of removal of the offending meniscus. This principle of high resistance-low repetition should be applicable to nearly all muscles and muscle groups in which increase in muscular power is the sought-for goal. The principles of this procedure are highly recommended to those interested in the treatment of this type of orthopedic condition.

Summary and Conclusions

In summary, the physical therapy department at this general hospital has, during the years of World War II, been concerned with two types of activities:

1. The training of physical therapists qualified to undertake the heavy responsibilities incident to the maintenance of the technical aspects of physical therapy on a high plane.

2. Professional considerations which have, in the main, concerned the treatment of amputations and thoracic, neurologic and orthopedic injuries.

If there is a lesson to be learned from the management of these cases, it is this: The quality of physical therapy varies inversely with the patient load; physical medicine has been, is and should be an individualized procedure. With this in mind, the professional experiences of World War II should contribute to the forwarding of the specialty of physical medicine.

12. DeLorme, T. L.: Restoration of Muscle Power by Heavy-Resistance Exercises, J. Bone & Joint Surg. 27:645 (Oct.) 1945.

ARCHIVES of PHYSICAL MEDICINE

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.·. EDITORIALS .·.

PHYSICS, BIOPHYSICS AND PHYSICAL MEDICINE

The recent rapid development in physical medicine has emphasized the importance of physics in the premedical curriculum. Although a year of physics has been a premedical requirement for a long time, it is felt that most courses have had the engineering rather than the medical slant. It is obvious that physical principles can not be changed, but, as suggested by Schmitt[1] in this issue of the ARCHIVES, illustrations of these principles can be drawn from the medical rather than from the engineering field.

Okkelberger,[2] during a symposium on preparation for the study of medicine in 1941, after remarking that physics courses are not always well adapted to the needs of the premedical student, suggested that, after a brief general course, the student be given special work in electricity, X-ray and radium. In an analysis of student and faculty opinions of premedical training made by the Illinois State Academy of Science Committee on Premedical Education[3] and reported at the Fifty-fifth Annual Meeting of the Association of American Medical Colleges in 1944, student opinion in the Chicago medical schools favored by almost three to one, instruction beyond the elementary course in physics to cover the principles of the induction coil, the electrocardiograph, X-ray equipment, vacuum amplifiers and generators, oscillograph and optical instruments with special reference to their use in medical research and practice. Opinion was divided among faculty members, however, since some felt that the medical student himself should be able to make the application of physical principles in medicine, while others asserted that medical students came into medical classes not realizing that electrical currents can be generated in living tissues or that the electrocardiogram is a record of electrical currents generated in the heart itself. The fact that medical students recognize the need of more direct application of physical principles to medicine in the premedical training is significant.

Among the 130 points gleaned by Sanger and Hurd[4] from 196 articles on the medical curriculum, one indicated the need for more emphasis on biophysics. As Schmitt[1] has reminded us, our present day medical sciences of anatomy, biochemistry and pharmacology are offshoots of the older science of physiology. Now we have a new science developing and rising to claim a place in the medical curriculum, biophysics. Schmitt has suggested that biophysics will probably enter the curriculum by "peaceful penetration" as did biochemistry and will doubtless be sponsored by the department of physiology, the department of biochemistry and the department of physical medicine. There seems to be no doubt at the present time that biophysics is to assume ever increasing importance in medical research and clinical practice.

1. Schmitt, F. O.: The Growing Importance of Physics in the Premedical and Medical Curriculums, Arch. Phys. Med. 28:71 (Feb.) 1947.
2. Okkelberger, P.: Symposium on Preparation for the Study of Medicine. III. Biology and Other Considerations, J. Assn. Am. Med. Coll. 16:79 (March) 1941.
3. The Illinois State Academy of Science Committee on Premedical Education: A Study and Analysis of Faculty and Student Opinions of Training in Preparation for the Study of Medicine, J. Assn. Am. Med. Coll. 20:226 (July) 1945.
4. Sanger, W. T., and Hurd, A. W.: What the Educator Thinks the Ideal Medical Curriculum Should Be, J. Assn. Am. Med. Coll. 21:8 (Jan.) 1946.

Krusen[5] stated that in the preliminary survey conducted by the Baruch Committee on Physical Medicine to determine the needs for the development of physical medicine in the United States, the importance of a better understanding of biophysics on the part of the medical profession became apparent. The Committee accordingly arranged with the Massachusetts Institute of Technology to furnish in its Department of Biology and Biological Engineering a program of training and research in physics and technology as applied in medicine. This is a graduate program which should help to train teachers and research workers who in turn can aid in the teaching program in biophysics and in physical medicine for undergraduate students in the medical schools.

Study of the physiologic action of the physical agents, which in the past has been more or less strictly physiological, will be aided and improved by the biophysical approach. However, the value of physiologic research in physical medicine done before the present emphasis on biophysics, should not be discounted. It is very doubtful if it will ever be possible to measure biological reactions with the same accuracy as purely physical processes. Nevertheless, the application of physical instruments and methods in the solution of fundamental problems in the field of physical medicine is a welcome prospect.

Our readers are urged to read the excellent article by Dr. Schmitt dealing with the teaching of physics in premedical and medical schools. It is a stimulating and thought provoking presentation of the need for a more adequate program of teaching and research in biophysics as a foundation for the scientific application of the physical agents in the treatment of disease.

5. Krusen, F. H.: The Future of Electronics and Electrical Instrumentation as Related to Medicine, J. Assn. Am. Med. Coll. 21:167 (May) 1946.

CHEMICAL TRANSMISSION OF THE MOTOR NERVE IMPULSE

The idea of the humoral or chemical transmission of the autonomic nerve impulse from the nerve ending to the tissue supplied is now over forty years old. In 1904, Elliott[1] suggested that sympathetic nerves might liberate adrenaline (epinephrine) at their endings. Dixon[1] in 1906 found that an extract of a dog's heart, stopped in vagus arrest, caused inhibition of the frog's heart, and postulated a chemical mediator which he mistakenly thought to be muscarine. In 1914 Dale[1] studied acetylcholine which he discovered in a sample of ergot. He observed the close similarity of its effects in animals to those of parasympathetic stimulation and suggested that it might be hydrolyzed by a blood esterase to acetic acid and choline although he had no evidence at that time that it existed in the animal body.

In 1921 Loewi[1] reported that the vagus nerve produced its inhibiting effect upon the heart by liberating an inhibitor substance at its endings in heart muscle. He found that this inhibitor substance exhibited pharmocologic effects identical with those of acetylcholine. In 1929 Dudley and Dale[1] identified acetylcholine for the first time in animal tissue in the spleen of an ox. Subsequent work has established beyond all doubt the importance of acetylcholine in the transmission of the parasympathetic impulse to the tissues supplied. In a similar manner, largely by the work of Cannon and his associates, epinephrine has been established as the chemical mediator for sympathetic nerve impulses.

As might be expected, the demonstration of the chemical transmission of autonomic impulses in smooth muscle led to the study of the transmission

1. Dale, H.: Chemical Transmission of the Effects of Nerve Impulses, Brit. Med. J. 1:835 (May) 1934.

of motor impulses in striated muscle. The work of Dale, Feldman, Vogt, Nachmansohn and others has shown that acetylcholine is the chemical substance responsible for the transmission of motor impulses in skeletal muscle. In fact the whole cycle of the hydrolysis of acetylcholine by cholinesterase and its resynthesis by choline acetylase has been worked out.[2]

Our consideration so far has been concerned with the physiology of contraction in normal muscle. What is the situation in denervated muscle which exhibits atrophy and fibrillation? For a discussion of this question, the reader is referred to the article in this issue of the ARCHIVES by Mead on the relationship of acetylcholine to fibrillation in denervated muscle.

2. Nachmansohn, D., and Machado, A. L.: J. Neurophysiol. 6:397 (Sept.-Nov.) 1943.

MEDICAL NEWS

REPORTS FROM ABROAD

Physical Therapy in Sweden

By K. G. Hansson, M.D., New York

Physical therapy in Sweden has always been closely associated with physical education. They were both initiated by Per Henrik Ling, who was responsible for the Royal Central Institute, which was started May 5, 1813 in Stockholm. At that time, following the Napoleonic Wars, Europe was interested in improving the human stock. Ling was a devoted student of the Greek Republic of Plato's time and tried to revive the ancient Greek doctrine of physical education based on human physiology and hygiene.

Ling's interest in exercises gave origin to therapeutic exercises used in medicine. Later the Royal Central Institute distinguished between training in physical education and what today is called physical medicine. At present this ancient school is located in new buildings next to the Stadium where the Olympic games were held in 1912. The new buildings were completed in 1944 during the war. They combine severe, classical architecture with the modern functional demand for good lighting and centralized organization. The lecture halls are modern in every sense. The students have their own cafeteria, library, rest rooms and locker rooms. The swimming pools have not been completed, but the gymnasiums are most impressive in their completeness and size.

The entrance requirements to the physical therapy course is the so-called student examen, which corresponds to two or two and one-half years of an American college course. It places more emphasis on foreign languages and less on philosophy and political sciences. In addition to the Royal Central Institute, there is the South Swedish Institute, in Lund. The two institutions have about the same requirements, curriculum and reputation. The entering student must be between 19 and 30 years of age. Special requirements such as good health and the student's aptitude for caring for the sick are important. There is no tuition; the only expenses are for personal equipment. The course requires two years, each beginning September 1 and ending June 21, with the usual holidays for Christmas and Easter.

The course for the first year includes anatomy, physiology and pathology; these subjects are given at the Medical School, with lectures and demonstrations in massage and therapeutic exercises as well as practical application among the students. Hygiene, first aid, and the ethics and psychology of handling patients are also on the students' program.

The second year is spent entirely in various hospitals, such as the Karolinska Sjukhuset and Vanforeanstalten, a modern orthopedic hospital. There the students attend lectures in thermo— and phototherapy, hydrotherapy, electrotherapy and mechanotherapy, and there they treat patients under strict supervision.

Some special lectures are given in neurology, gynecology, psychiatry and other specialties, and many special hospitals are visited, where the students are present at several operations. Most of the teaching

is clinical; the patients are presented, and the physical therapy aspect is discussed. At the end of the second year the students receive a diploma from the Royal Central Institute and a license from the Royal Medical Board.

The Institute has fourteen instructors and additional instructors in the hospitals. The faculty is headed by Professor Christiansen, a well known physiologist, whose research laboratories are among the most modern and most beautifully equipped. The clinical teaching is headed by Dr. N. Silfverskold, who is an orthopedic surgeon; Dr. Petren teaches anatomy; Dr. Fischer, hygiene; Dr. Henschen, pathology; Dr. Soderlund, psychology, and Dr. Sisepky supervises the physical therapy clinic. These are all outstanding men in their special fields.

The graduates find positions in hospitals or in doctors' offices, or they practice independently and accept patients on physicians' prescriptions. The custom has been in force for many years, and there has been no complaint from the physicians of abuses of privileges or of malpractice.

Physical Therapy Today and Tomorrow

By Prof. Dr. J. Grober, Institute of Physical Therapy of the University of Jena, Jena, Germany

The four types of scientific therapy — medical, dietetic, surgical and physical — have been variously affected by Germany's loss of the war. The first two forms of treatment have suffered most. However, in view of the immense damage which their lack has inflicted upon the health and the working capacity of the German people, the proper agencies are to take all necessary measures to secure a sufficient supply of drugs and suitable diets for sick persons. The deficiency in essential materials is also felt, although to a lesser extent, in the other two modalities of treatment. Anesthetics, dressing materials and surgical instruments have become scarce, and the meager reserves are being rapidly used up. In physical therapy, the curtailment of power facilities, as well as the impossibility of replacing the badly worn physical therapy instruments and apparatus, already apparent in 1933 and more so since 1939, is now becoming more and more noticeable.

Concurrently, owing to the war and postwar conditions, the number of patients referred for surgical and physical treatment has reached an all-time high. Countless victims of injuries and accidents, the results of advanced technics of modern warfare, fill the surgical wards. Chronic diseases and degenerative lesions, directly or indirectly induced by the war among the military personnel and the civilian population alike, bring an infinitely greater number of patients to the physical therapist. In addition, there are a host of diseases which arose primarily during the war years as result of overexertion and a diet deficient in quality as well as in quantity and subsequently became enormously increased because of lack of proper drugs and dietetic treatment.

By the end of World War I the medical profession of all nations realized that the remedial measures of physical therapy are indispensable for the control of health conditions brought on by the war. Therefore most countries have included physical medicine among the required and examinable subjects of medical curriculums. Many universities have duly established physical therapy institutes. In Germany, however, this problem did not receive the attention it did elsewhere. Only four universities, those of Berlin, Munich, Frankfurt and Jena, provided physical therapy institutes, despite the fact that the Department of War Medicine and the social agencies requested them. In a comprehensive report on the inclusion of physical therapy in the medical curriculum, read before the Fifth International Congress of Physical Therapy, I stated that there were only twelve, including Germany, out of seventy countries, which did not have physical therapy included by legislation in the required courses to be attended by the medical students.

World War II has brought the following advancement in the Russian-occupied zone of Germany: During one semester of their clinical studies, the medical students must attend a two hour lecture course on physical therapy. Whether it is more expedient to organize such lectures on the basis of purely technical instructions or whether the students should be taught the clinical application of physical therapy, (e. g., treatment of infectious, pulmonary or cardiac diseases, etc.) is a matter of opinion. I believe in a combination of the two.

The students must first learn the present state of physical therapy methods. Many of these they will find later indispensable in their daily practice. However, it should also be impressed upon their minds that physical therapy is far from being in the final stage of its development. This is true not merely of the technical progress. An enormous advance is to be expected in the clinical application of physical therapy as soon as atomic research releases the great and new energies for peacetime use. Then, as I predicted as early as 1919, on the basis of experiments by Pauli and me on the biologic effects of cathode rays, not

only shall we be able to utilize entirely new, hitherto unknown, forms of energy—to a certain extent as continuations of the electromagnetic energy spectrum, presumably in a very intensive and precisely limited form, and for many severe diseases—but we shall also have at our disposal, in place of the simple power modalities like gas and electricity, entirely different technical facilities for the operation of our physical therapy apparatus. The freeing of these important energies for peacetime—in this case for therapeutic—use, after completion of the atomic research, will constitute an incomparable enrichment of available therapeutic measures.

New York Society of Physical Medicine

The following program was presented at the February meeting of the New York Society of Physical Medicine: "Rehabilitation of the veteran," Donald A. Covalt, M.D., Assistant Medical Director, Medical Rehabilitation and Physical Medicine, Veterans Administration, Washington, D. C. (by invitation); "Comeback Civilian rehabilitation," Frederic G. Elton, Chief Supervisor, Division of Vocational Rehabilitation, New York State Department of Education (by invitation). Drs. Howard A. Rusk, George Deaver, Harry Kessler and Nila K. Covalt participated in the discussion.

The officers elected for 1947 are: President, Karl Harpuder, M.D.; Vice-President, Michael J. O'Connor, M.D.; Treasurer, Richard Kovács. M.D.; Secretary, Madge C. L. McGuinness, M.D. The Executive Committee is composed of Chairman, Harold Neifeld, M.D., H. J. Behrend, M.D William Bierman, M.D., I. D. Stein, M.D., and Jerome Weiss, M.D.

Consultants in Physical Medicine Named

Dr. H. Worley Kendell, President-Elect of the Congress and Dr. Charles O. Molander have been named consultants in physical medicine to the Percy Jones General Hospital, Battle Creek, Mich.

University of California Course on Cerebral Palsy

Mrs. Mildred Shriner, who conducted the first course on "Educational Treatment of Cerebral Palsied Children," at the University of California, Berkeley, during the summer session of 1946, reported on special features of the course in the September, 1946 issue of *California Cares,* the bimonthly bulletin of the California Society for Crippled Children, San Francisco.

Members of the class included teachers working with cerebral palsied children, teachers of homebound children, county speech teachers, one County Supervisor of Child Welfare, occupational therapists, physical therapists, nurses, and two persons who had cerebral palsied children in their own families.

Special guest speakers, demonstrations with children, movies, and field trips to schools brought attendance from 50 to 250 interested people.

The topics studied included adaptation of teaching materials and equipment for the individual child; methods in classroom and home activities which aid hand coordination, walking and speech; social, emotional, and intellectual development of the child as integrated with the total school learning program; research and educational experiments.

The course included guest speakers on the medical aspects of cerebral palsy; special demonstrations with children and lectures by speech therapists; guest speakers on hearing and other educational problems; parents' problems and aid to the child. Vocational rehabilitation was discussed by two successful cerebral palsied adults.

Most of the lecture material which was presented cannot be found in textbooks. It was based on training and successful experience of those who participated. Through the splendid cooperation of the California Society for Crippled Children, the National Society for Crippled Children and Adults, and the Spastic Children's Society of Alameda County, printed material was gathered together and given to members of the class. A library on the problem of cerebral palsy was collected and given to the University Library.

Another course on the "Educational Treatment of Cerebral Palsied Children" is being given at the University of California at the present time.

Surgeon Catalogues Nervous Reactions

Seven distinct nervous reactions developed among the men who flew "the hump"—the air supply route from India to China across the Himalayas—during the war.

Continuous service on this cloud road probably provided the most severe nerve strain endured by Army air men and study of the observed symptoms, as reported to the Surgeon General's Office by Major William M. Jeffries of the Medical Corps, a Flight Surgeon of the Air Transport Command in the China, Burma, India Theatre, discloses what might be expected when men are pressed toward the limits of human endurance.

The fact that many showed no symptoms at all, Major Jeffries stresses, is a high tribute to the men who composed this force.

The "hump" route, as he describes it, was over a series of high, jagged mountain ranges divided by rivers flowing through precipitous gorges. There were no emergency landing fields. Much of the way was over Jap-held territory. Storms frequently blew ships far off course. Icing conditions were often bad, yet de-icing equipment had been removed from most planes. Flights were made at altitudes of from 17,000 to 35,000 feet, yet oxygen equipment was often inadequate; usually passengers had none. Landing fields were endangered by low ceilings and ground fog. Surrounding high mountains allowed no margin for error in instrumental letdowns. On the ground, heat and humidity were so great that clothing was constantly drenched with persiration. Prickly heat was almost universal and sleep almost im-

possible. There was constant danger from snakes and insects—certainly annoyances.

The combination of these factors, says Major Jeffries, was sufficient to shake the stability of some of even the soundest individuals, a large number of psychologic disorders developed, and it was remarkable that more were not encountered.

Psychiatric cases were occurring in large numbers in Italy in the late winter and spring of 1944. This led to a clinical study of individual cases, and a study of men exposed to the same stresses who showed no abnormal nervous reaction.

There is no such thing, the psychiatrists conclude, as "getting used to combat." In the North African Theatre, for example, practically all infantrymen who were not otherwise disabled ultimately became nervous casualties. There was general agreement between both medical and line officers that 200 days in combat, not necessarily continuously, represented about the limit of human endurance. By that time if a man had not definitely "cracked up" he had become so jittery that he was ineffective as a soldier and a demoralizing influence among his comrades.

The British, however, believed that a man could stand 400 days and attributed the difference to their policy of pulling an infantryman out of action at the end of 12 days or less for a rest of at least four days. American infantrymen in Italy frequently stayed in combat continuously 30 to 40 days and occasionally as long as 80 days.

The report recommends that the limit of combat for any infantryman be 210 days—and this only in extreme emergency. It also urges that special recognition and privileges be given infantry soldiers, that greater efforts be made in indoctrinating soldiers and that categories and channels of evacuation be clarified for both line officers and medical officers to the end that true malingerers will not be evacuated and severe psychoneurotics not retained in their combat units.

The war ended before recommendations of this report could be put into practice.

Order

At a meeting of the Federal Communications Commission in its offices in Washington, D. C., on December 26, 1946,

The Commission having under consideration a request for assignment of a frequency in the 3000 megacycle region of the radio spectrum for industrial, medical, and scientific purposes without a lisense; and

The Commission on December 18 and 19, 1946, having held a public hearing, after due notice to all interested parties, to receive evidence upon the question whether such a band should be assigned for such purposes; and

The Commission having considered the evidence presented during such hearing and having determined upon such consideration that the public interest, convenience, and necessity would be served by such an allocation;

Now, therefore, it is hereby ordered, that the frequency 2450 megacycles be, and the same is hereby assigned, for industrial, medical and scientific purposes on a non-exclusive basis. Operation for such purposes upon the frequency 2450 megacycles may be conducted without a license only on the following conditions:

(1) The emissions of radio frequency energy resulting from such operation shall be confined to that portion of the spectrum between 2400-2500 megacycles.

(2) The energy radiated and the band width of emissions of all industrial, medical and scientific equipment operated as provided for herein shall be reduced to the greatest extent practicable. No interference shall be caused to authorized communication services from spurious or harmonic radiations. In the event of such interference, from spurious or harmonic radiations, operation of the equipment causing such interference shall cease and shall not be resumed until steps necessary to eliminate such interference have been taken.

(3) Operation upon the assigned frequency as specified above shall be subject to such future regulations as may be found by the Commission to be appropriate.

By direction of the Commission,
T. J. SLOWIE, Secretary.

Hospitals Approved for Residency Training in Physical Medicine

[1]Los Angeles County Hospital, Los Angeles.

[1]Massachusetts General Hospital, Boston.

Mayo foundation, Rochester, Minnesota.

Michael Reese Hospital, Chicago.

[1]Montefiore Hospital for Chronic Diseases, New York City.

[1]Mount Sinai Hospital, New York City.

Passavant Memorial Hospital, Chicago.

[1]Presbyterian Hospital, New York City.

St. Luke's Hospital, New York City.

Stanford University Hospital, San Francisco.

[1]State of Wisconsin General Hospital, Madison, Wisconsin.

[1]University of California Hospital, San Francisco.

[1]University Hospitals, Minneapolis, Minnesota.

Walter Reed General Hospital, Washington, D. C.

University of Kansas Hospital, Kansas City, Kansas.

[1]Goldwater Memorial Hospital, New York City.

[1]Hospital for Joint Diseases, New York City.

[1]Cleveland Clinic Foundation, Cleveland, Ohio.

[1]Hospital of the University of Pennsylvania, Philadelphia.

[1]Medical College of Virginia, Hosp. Div., Richmond, Va.

[1]Veterans Hospital, The Bronx, New York City.

1. Indicates temporary approval.

The Birtcher Scholarship Fund

The establishment of the Birtcher Scholarship Fund at the College of Medical Evangelists by the Birtcher Corporation of Los Angeles was announced in these columns in 1945. The purpose of the Fund is to stimulate interest in physical medicine among undergraduate medical students. Awards are made to sophomore and junior students on the basis of theses on selected topics in this field. The topics suggested by the Birtcher Scholarship Committee for the current year are: (1) Early Mobilization of Surgical Patients; (2) The Physical Therapy of Rheumatoid Arthritis; (3) Heliotherapy. About thirty students have signified their intentions of submitting papers. Approximately $700 will be distributed in awards ranging from $25 to $200 for the best ten essays. Judges will be chosen outside the medical school faculty. Awards will be announced at the annual commencement exercises in June.

Physical Reconditioning Opportunities

Officers who have had training and experience in physical education will be interested in the opportunities offered by the Army's new physical medicine service. Physical reconditioning, occupational therapy, and physical therapy have been combined in this new service which will be on a level with other major services in the larger hospitals. It will be under the supervision of medical officers trained in physical medicine. The physical reconditioning program offers to Medical, Medical Administrative, Pharmacy, and Sanitary Corps officers splendid opportunities for service and advancement in a new field.

Plans are under way for the establishment of a school for the training of physical reconditioning officers and enlisted men. It will be located at one of the Army medical centers. The prerequisites for officers seeking to enter this school are: (1) previous military experience, (2) a minimum of 2 years' training in physical education at college level, or its equivalent in experience, and (3) demonstrated ability for leadership. The requirements for enlisted men are in line with those of the officers.

The course will be 8 weeks in duration and will have a wide scope. It is planned to give a thorough review in anatomy. kinesiology, and physiology. In addition, medical orientation and the administration and organization of the physical reconditioning program will be covered. Specific training in the methods and technics of physical reconditioning will be stressed. Management of supplies, equipment and facilities, together with personnel problems, will receive attention. Orientation in occupational therapy and physical therapy will be emphasized in order to secure the closest possible coordination between these activities.

Because of the present critical shortage of officers in this service, officers who have had service in reconditioning and who have been separated are being sought for return to active duty and possible integration into the Regular Army. Officers in the Army who have the prerequisites for this type of service and who are not presently assigned to it are urged to give careful consideration to the possibility of such assignments. Enlisted men who have the necessary qualifications and experience are urged to apply for Medical Department O. C. S. training in order to qualify for officer assignments in physical reconditioning. Civilians who have the background of training and experience in physical education but who have no military training are also being sought for military training in order to qualify for this work in the Army.

Officers desiring further information should communicate with the Chief of the Physical Reconditioning Branch, Physical Medicine Consultants Division, Office of The Surgeon General, War Department, Washington 25, D. C.

Isolation of Polio Virus

Successful isolation of what they believe to be nearly pure polio virus has been accomplished by two Stanford scientists, Dr. Hubert S. Loring and Dr. C. E. Schwerdt, has been announced by Stanford University.

Laboratory tests, including photographs taken through an electron microscope, indicate that the isolated virus is 80 per cent pure or better, according to the two Stanford chemists.

The experiments, carried on in the Department of Chemistry laboratories at Stanford, were financed by the National Foundation for Infantile Paralysis, sponsors of the annual March of Dimes drive, from funds allocated to research on polio.

Production of purified virus is seen as an important step in the long and to date unsuccessful laboratory struggle to produce a vaccine effective against poliomyelitis.

Now that a virus which is relatively pure is available, the experimental door is open, Dr. Loring pointed out, to render the pure virus noninfectious by chemical or physical treatment, and, the scientists hope, to produce a concentrated vaccine free of the impurities which have plagued previous polio vaccine experimenters.

He cautioned against any conclusion that isolation of the pure virus will lead necessarily to production of a successful vaccine against polio, and stated that a long and exacting experimental path lies ahead of scientists seeking this vaccine.

First, with the virus produced from a single type of polio at Stanford—and there are many different polio strains—the two scientists will attempt to produce a vaccine effective for cotton rats, which happen to be suspectible to the type of polio, known as the Lansing strain, on which Dr. Loring and Dr. Schwerdt have experimented since 1943.

Then similar vaccines must be prepared from other strains to which other experimental animals, such as mice, are susceptible. Later the vaccines must be tried on monkeys, which are suspectible to most strains of polio, before the final stage can be reached when the vaccine can be tried on human beings. First step in the technic of the two scientists is the grinding up of the brain and spinal cord of cotton rats which have been infected with polio through injections. Approximately 150 Gm. of this tissue, after numerous purification processes involving the use of a high-

speed centrifuge and of chemicals to extract impurities, is reduced down finally to about a milligram of the nearly pure virus protein. In order to prevent chemical decomposition which occurs at higher temperatures, all the purification procedures are carried out at low temperatures, from 0 to 4 C.

Dr. Loring said that the tests indicated that this virus material has characteristics similar to other viruses which have been purified, and that it behaves both chemically and physically in a manner which would not be likely scientifically if more than one type of material were present.

According to the Stanford scientists, one of the contributions to the knowledge of polio which has resulted from this work is that scientists now know what the virus looks like, know how big it is, and what its chemical characteristics and properties are.

The virus, seen by means of the electron microscope, is a relatively spherical particle which is so infinitesimal in size that its diameter is estimated at 25 millimicrons, or 25 billionths of a meter. Chemically, the virus reacts as a protein, which the two chemists believe it to be.

Cooking With Radar

By its action of December 26th in making the frequency of 2450 megacycles available for immediate use of diathermy and industrial heating equipment, the Federal Communications Commission recognizes the public and commercial benefits which may be expected from harnessing electronics to medical, household and commercial use.

Diathermy apparatus is invaluable as a therapeutic means of heating interior areas of the body to combat human ailments. By the same token, electronic heating gives promise of revolutionizing cooking methods and speeding up other heating processes, such as drying plywood, airing rubber and plastics, surface hardening of metals, testing material and equipment, etc.

For example, in a hearing which preceded this step, one company testified that its new "radarange," by using the magnetron tube developed in connection with radar for war purposes, can pre-cook food in seconds as compared with minutes by older methods. It demonstrated that, by such means, frankfurters, say, can be grilled in 8 to 10 seconds, gingerbread and biscuits baked in 29 seconds, and hamburgers with onions made ready in 35 seconds. In addition, frozen food can be prepared immediately without thawing.

Electronic devices heat uniformly from the inside to the outside, which is just the reverse of ordinary heating apparatus. The former does not, as some people might suppose, draw heat from the electromagnetic spectrum itself. Instead, it plugs into the regular power supply line. Its secret is in stimulating electromagnetic impulses which are beamed upon the food or other object. Heating is effected by dissipating the energy generated in the object being treated.

Some of this radiation naturally escapes, to invade the radio spectrum on corresponding frequencies. This can cause interference to authorized radio communication, particularly safety services such as police and aviation, and also to FM, television, and even telephone lines. At previous hearings, for instance, it was testified that the energy thrown off by diathermy machines have blanketed Chicago's police radio system for half an hour at a time. One Army Air Base had to practically close down its radio communication whenever a single diathermy machine only four miles away started operating.

The solution is to have electronic heating equipment designed so as to discharge excess radiations into appropriate frequency bands where they will not collide with communication transmissions on other ether paths. In other words, the emissions from industrial, medical and scientific apparatus on the newly authorized frequency must be confined between 2400 and 2500 megacycles, subject to regulations which may be adopted in the future. This obviates the necessity of licensing such apparatus. The net result is to further rather than handicap the utilization of electric heating equipment for home and business purposes.

Airborne Infections

Dr. R. E. Dyer, Director of the National Institute of Health, U. S. Public Health Service, Federal Security Agency, issued the following statement on the use of glycols and ultraviolet radiation in the control of airborne infections, to answer numerous inquiries from the public:

During the past few months, several articles have appeared in the public press relative to the possible efficacy of glycol vapors and ultraviolet radiation in reducing certain infectious diseases, particularly upper respiratory diseases, such as the common cold. Due to the fact that many inquiries have been made as to the possibility of using one or both of these methods in public buildings, it is felt that a statement at this time should be made concerning the use of such installations.

Committees of the National Research Council and the American Public Health Association have studied and reviewed the data on such installations. Within the past several weeks, these two committees separately have submitted reports. Both of these committees feel that the use of either glycol vapors or ultraviolet radiation is still purely in the experimental stage and that the data collected so far do not warrant the installation of such equipment in public buildings and industry in the hope of cutting down upper respiratory infection. The U. S. Public Health Service, through its research organization, the National Institute of Health has conducted rather extensive studies on both gylcol vapors and ultraviolet radiation and fully concurs in the reports and recommendations made by the committees of the National Research Council and the American Public Health Association. It must be emphasized that direct unshielded ultraviolet radiation of sufficient intensity to kill microorganisms in the air is also harmful to the eyes and exposed skins of humans. These observations are not intended to indicate that the future will or will not disclose new public health values in the application of either glycols or ultraviolet radiation. Much experimentation is needed, however, before a decision can be made as to whether such application may or may not be warranted.

Obituary

We regret to announce the death of two of our members, Dr. Samuel Barbash of Atlantic City, N. J., and Dr. Joseph O. McKenney of Beaver Dam, Kentucky.

BOOK REVIEWS

ELECTRONS IN ACTION. By *James Stokley.* Fabrikoid. Price, $3.00. Pp. 320, with 55 illustrations and 32 plates. New York and London: Whittlesey House, McGraw Hill Book Co., Inc., 1946.

This is the work of a highly qualified writer of science. It presents a popularly written, yet scientifically correct and profusely illustrated story of what electrons are and what they offer to mankind according to our present state of knowledge. The author begins with an account of what electrons are, where they come from and gives a live account of the pioneering in the field. By means of apt similes and examples, he explains the elements and characteristics of electron tubes and discusses their applications in the many fields of electronics. There is an excellent explanation of frequency modulation and its promises for post-war broadcasting, as well as television, its workings and future adaptations. The discussion of cosmic electronics reveals some of the newest knowledge about the effect of the sun and the moon on radio on the earth and is unique in books on electronics. Other chapters deal with the part electronics plays in industry, of the electronic recording of sound, the computer, the high voltage x-rays, the betatron, the electron microscope and the various applications of electronics to medical instruments, such as the Berman metal locator, the inductotherm, and the electroencephalogram. Outstanding are the chapters on radar, loran and the atomic bomb. Every progressive citizen will want to read this fascinating story with its thoroughly practical presentation.

THE CHALLENGE OF POLIO (The Crusade Against Infantile Paralysis). By *Roland H. Berg.* Cloth. Price, $2.50. Pp. 208. New York: The Dial Press, 1946.

This book, written by a lay author, is a clear and concise discussion of the history of research and other knowledge of poliomyelitis. It was written primarily for the lay public; however, considerable not commonly known information is given which is of interest to physicians.

In the introduction Mr. O'Connor, President of the National Foundation for Infantile Paralysis, stated, "The author has attempted to explain truthfully and understandably scientific research of poliomyelitis so that those who sponsor the research might know what has been accomplished."

The author presents results of much of the research on treatment of poliomyelitis, particularly form 1916 to 1946. He has vividly described the enthusiasm which arose after each of the new developments in the treatment and to what extent each of these various procedures is used now.

The controversial reports of Sister Kenny's work are fairly well understood by those who have been closely associated with the treatment of poliomyelitis. However, much could be said to clarify some of the problems relative to the Kenny treatment as far as a large part of the medical profession and lay public is concerned. The author has partially accomplished this by giving what appears to be the present-day opinion in general of the Kenny treatment. The unfavorable results have been included in this review of her work. The results of treatment as reported by the Kenny Institute are given. This report indicates that the percentage of deaths, permanent "crippling" and the need for braces or crutches at the Kenny Institute is about the same as it is in any epidemic of poliomyelitis. The statistics given concerning results at the Kenny Institute are comparable to those at other institutions in which poliomyelitis is treated regardless of the kind of treatment.

All physicians interested in poliomyelitis should read this historical account of the crusade against poliomyelitis. The book can be highly recommended to patients desiring authentic information on this subject. Berg admits he has not covered all of the material published on the subject in the past twenty years but the material which he presents seems to indicate that his opinion is unbiased.

THE HUMAN EAR IN ANATOMICAL TRANSPARENCIES. Descriptive text by *Stephen L. Polyak,* M.D., Professor of Anatomy, University of Chicago; Anatomical Transparencies and illustrations by *Gladys McHugh,* Medical Illustrator, the University of Chicago Clinics; Anatomical Preparations by *Delbert K. Judd,* M.D., Assistant Professor of Otolaryngology, the University of Chicago. Cloth. Price, $10.50. Pp. 136, with 83 illustrations. Published under the auspices of Sonotone Corporation. Distributed by T. H. McKenna, Inc., New York, N. Y., 1946.

This unusual book is undoubtedly the most valuable contribution to our knowledge of the anatomy of the ear and its surroundings. The only criticism that one could make is that its title is far too modest. Not only does it cover far more than the ear, but the transparencies included in the book are only part of a wealth of illustrations that leave the reviewer with a profound admiration for what the producers of this book have wrought. The book is divided in two main sections, the first one is on the gross anatomy of the auditory apparatus and the organs of speech. This includes 12 transparent dissections at actual size of the ear and head and neck. It also contains numerous drawings in color of the larynx. The second part which contains 8 transparencies also contains nu-

merous colored and uncolored illustrations of the finer structures of the ear. The transparencies in this section are 3 times actual size. The quality of the illustrations is superb.

The text written by Dr. Polyak which accompanies the illustrations is a clear description of the anatomy involved. It goes into the function of the organs involved only superficially, just enough, in fact, to make the anatomical descriptions take on meaning.

One does not know what to admire more, the work that went into the writing of the text and the collection of the material, or the work that went into the making of the large number of anatomical preparations needed, or the work involved in making the drawings. It is impossible to express in a review the extraordinary qualities of this book. For that one will have to secure a copy and see for one's self. The extremely low price for the value received is a minor miracle in itself.

This reviewer would like to suggest to author and illustrator that if it could be done, a book like this on the central nervous system might be another equally valuable contribution.

MEN UNDER STRESS. By *Roy R. Grinker*, Lieut. Col., MC. and *John P. Spiegel*. Major, MC, Army Air Forces. Cloth. Price, $5.00. Pp. 484. Philadelphia: Blakiston, 1945.

This book accommodates a varied group of readers, ranging from the interested lay person to the technical and professional expert in the field of psychosomatic medicine and psychiatry. It deals almost exclusively with air force personnel in the European theatre. By the very reason of the intensity of the demands made on this group, the authors were able to observe and describe the basic functioning of the personality of the soldier in situations of external stress, as the title implies.

The book is well developed. The introduction of the subjects, the men, the locale and the environment of combat, is followed by a description of reaction to combat, reaction after combat and applications of the observations to civilian practice. Discussions on reactions in combat and reactions after combat are highly instructive as to the dynamics of those reactions. The explanation serves to clarify controversial points which have clouded the interpretation of war neuroses. For example, war neurosis or "operational fatigue" is a term used in the book to describe reactions of the soldier in the combat theatre but not of the returnee who has been dismissed from foreign service to return home for hospitalization and psychiatric care. The impression conveyed is that the term "operational fatigue" is acceptable to the authors only to describe a certain type of occupational disturbance (that is, a situation of severe physical, mental and emotional strain) and, therefore, that the reaction is rather promptly reversible. This reaction is contrasted with the prolonged neurotic reaction in which operational stress merely served to activate a previously dormant neurosis. The authors consider operational stress in the prolonged neurotic reaction to be analogous to the incidents which precipitate traumatic neurosis in civilian life. The extreme variability in the amount of stress which an individual can endure before the breaking point is reached appears to have a direct relationship to his psychologic preparedness to react to specific stimuli. Although all the reactions are regressive in a psychologic sense yet for purposes of description and clarification of psychodynamics, the authors have classified the reactions as passive-dependent, psychosomatic, guilt-depression, aggressive-hostile and psychotic-like states.

The chapters dealing with treatment are unusually informative and detailed—a pleasing departure from the more frequently encountered lumping of a description of all psychotherapy into a few brief paragraphs that deal with generalities of the most abstract nature.

The final section deals with applications to civilian practice and is particularly valuable to the physician or social worker who has not had war experience, though it probably could be read with profit by all physicians and social workers because they would have the privilege of seeing these problems through the trained observing eyes of the authors.

HIPPOCRATIC WISDOM. A MODERN APPRECIATION OF ANCIENT SCIENTIFIC ACHIEVEMENT. By *William F. Petersen*, M.D. Cloth. Pp. 263, with 77 illustrations. Price, $5.00. Springfield, Ill.: Charles C. Thomas, 1946.

"Whoever wishes to pursue properly the science of medicine must proceed thus. First he ought to consider what effects each season of the year can produce; for the seasons are not at all alike, but differ widely both in themselves and at their changes. The next point is the hot winds and the cold, especially those that are peculiar to each particular region.

"For knowing the changes of the seasons and the risings and setting of the stars with the circumstances of each of these phenomena, he will know beforehand the nature of the year that is coming. Through these considerations and by learning the times beforehand he will have full knowledge of each particular case, will succeed best in securing health and will achieve the greatest triumphs in the practice of his art. If it be thought that all this belongs to meteorology, he will find out, on second thought, that the contribution af astronomy to medicine is not a very small one but a very great one, indeed. For with the seasons men's diseases, like their digestive organs, suffer change."

Hippocrates wrote this preface over the portals of his medical edifice, and the author uses it as a preface for this book. Dr. Petersen who was professor of pathology at the University of Illinois from 1920 to 1942 will be remembered as the author of a series of books: "The Patient and the Weather."

Why bother with Hippocrates when there is so much to learn in modern tests? Dr. Petersen who

has studied so much about the influence of the weather on the patient shows that the student obtaining knowledge and skill only at the top levels of the modern medical skyscraper should know something of the foundation structures and the service plants in the basement and sub-basement if he is to be something more than a technician.

This book shows that our ideal physicians and the Hippocratic ideal were the same, not only ethically but intellectually. One does not treat a disease but a sick man, an individual, yet not an isolated individual, but a member of a group. One must survey the whole field. It is still true that in the lives of most human beings the relation of the physician and patient is fundamentally what it was in the age of Hippocrates. Consequently this book can be recommended to the medical students and all physicians.

HANDBOOK OF DIET THERAPY. Written and Compiled by *Dorothea Turner* for the American Dietetic Association. Cloth. Pp. 112. Price, $2.00. Chicago: University of Chicago Press, 1946.

This is not just another book on diet. Summarizing the most recent studies in this field made by committees of the Diet Therapy Section of the American Dietetic Association, the National Research Council and the Bureau of Home Economics and Human Nutrition of the Department of Agriculture, this handbook clarifies dietetic terminology and offers a shortened method for dietary analysis. As stated in the announcement, the dietitian interviews the patient who needs help in planning and executing his diet. With the skill of a social worker or psychologist, the dietitian discovers the physical hindrances that the patient may face in carrying out the orders of the physician and the psychologic resistance he may feel toward beneficial foods or even toward the idea of a dietary regimen. The handbook is intended for students in home economics, nurses, physicians and trained dietitians.

APPLICATIONS OF GERMICIDAL ERYTHEMAL AND INFRA-RED ENERGY. By *Matthew Luckiesh,* D.Sc., D.E., Director, Lighting Research Laboratory, Lamp Department of General Electric Co., Nela Park, Cleveland. Cloth. Pp. 463, with illustrations. Price, $5.50. New York: D. Van Nostrand Co., Inc., 1946.

The author who is well known in the field of research in light, seeing and vision gives in his latest book various aspects of ultraviolet and infra-red energy. They include the use of germicidal energy for disinfecting air, water and other materials; the production of artificial sunlight for specific and general purposes, not only for specific use in lighting of the future but also in special therapeutic purposes.

The wavelengths of the various spectral regions of the entire spectrum of radiant energy are discussed and graphically illustrated in a manner readily understood by those who have not had the background a physicist brings to this field.

In the chapter on sunlight and skylight there is much information given by detailed discussion of the radiant energy from the sun, sunshine and cloudiness, ultraviolet component of solar energy, erythemal effectiveness of skylight together with a six-year record of erythemal effectiveness.

There is still confusion and unwieldiness in the use of terms. Nevertheless the same fundamental laws, not too many, if mastered by the person not a physicist will guide one through this field of science and without their knowledge it is foolish to worry too much about actual terminology.

The chapter on infected communal air will give much information which will again guide one as to the efficiency and claims made for air disinfection.

An extended list of references is appended which in itself would bear out the extensive interest and knowledge of the author. Those who have followed the long and tedious development of the field of therapeutic application of ultraviolet and infra-red energy, will want this book. For those just entering the field the book will serve as a fine text or reference.

THE EMBRYOLOGY OF BEHAVIOR. THE BEGINNINGS OF THE HUMAN MIND. By *Arnold Gesell,* M.D., Ph.D.. Sc.D., in Collaboration with *Catherine S. Amatruda,* M.D. Cloth. Price, $5.00. Pp. 289, with illustrations. New York and London: Harper & Brothers, Publishers, 1945.

By means of this book Gesell has made another worthy contribution in the important field of growth and development. The book is liberally supplied with photographs from excellent documentary motion pictures of the growing child in action. The text and these photographs give a correlated picture of actual behavior which is more complete than a description of the mere motor and perceptive developments of the infant. Development of personality through integrative physiologic functioning is implied and emphasized throughout this book as growth of an action system rather than growth of bodily systems.

The first three chapters afford a readable and vitalized review of embryology. The next three chapters deal with the genesis, motor structure and growth of fetal behavior. If only one chapter were to be read in this book, I would recommend that it be the chapter on breathing behavior in which the important function of breathing, "in many respects the most complex of all action patterns," is described in a highly instructive manner. Muscle tonus and the electrotonic synaptic drive, described in succeeding chapters, and breathing are classed as the interdependent master attributes.

The author next records factual data related to mechanisms of growth or behavior in the fetal and circumnatal infant and makes observations concerning these data. Again excellent illustrations are provided. The speculations and inferences of the author and the social implications of fresh recognition of growth function in behavior formations make the last three chapters, especially, highly interesting and stimulating reading. Reference is made in these chapters to the ever-

exciting subject of genius. The forty-eight pages of photographs of patterns and sequences provide an informative supplement to the author's observations.

EVOLUTION OF PLASTIC SURGERY. By *Maxwell Maltz,* B.S., M.D., Sc.D., F.I.C.S., Director, Department of Plastic and Reconstructive Surgery, West Side Hospital and Dispensary; Honorary Professor of Surgery, Universities of Santo Domingo, Nicaragua, Honduras, San Salvador, Guatemala; Fellow, Mexican College of Military Surgeons; Fellow, Brazilian College of Surgeons and International College of Surgeons. Cloth. Pp. 368, with 108 illustrations. Price, $5.00. New York: Froben Press, 1946.

This is an account of reparative surgery, particularly rhinoplasty starting from ancient times. In the first chapters Egyptian, Indian, Greek and Roman surgery is described with numerous interesting illustrations. From the middle ages through the nineteenth century short bibliographic sketches of notable surgeons are given, showing the development of technics. Rapid improvement is traced to the discovery of anesthesia and asepsis. The many methods of skin grafting devised in World War I and still used today are mentioned with emphasis on repair of facial defects. The final section is composed of photographs showing results of plastic surgery for a variety of congenital and traumatic deformities. A chronology of all the important dates in the evolution of plastic surgery from 5000 B.C. to 1945 is found in the appendix. This is a book of great interest to all surgeons and historically minded physicians.

RECREATION AND THE TOTAL PERSONALITY. By *S. R. Slavson.* Cloth. Price, $3.00. Pp. 205. Association Press, 347 Madison Ave., New York 17, 1946.

The reduction of work hours in shop and office, the small family, and automatic homemaking devices have greatly increased leisure and idleness. This in turn has created the necessity for devising means for utilizing the extended leisure time constructively, from the points of view of both individual growth and community health. This work is an analysis of the goals and methods of recreation's contribution to wholesome living, a ground breaking attempt to unite the factors, forces and groupings in recreation. The author emphasizes that a store of artifices, games and facilities, though important, are not in themselves sufficient to serve the newly evolving requirements. There has been growing a new awareness of the potentials of the human personality and of the conditions for total health. Since the chief value of recreation is in that it balances the human organism, physically and psychologically, it must be based on self choice, initiative and spontaneity. The cultural setting in which recreation occurs needs to be kept in mind as well. The headings of the ten chapters of the volume are: The nature and scope of recreation; unconscious motivations; fitting recreation to the individual; recreation and the democratic culture; the problem of competition; a demonstration of the new recreation; constants, variables and differentials; leadership and recreation and supervision; a creative relation; community resources. In these chapters the author purposely underplays the neuromuscular and physical aspects of recreation and as a craft and rather stresses the unconscious emotional drives and the social and community elements. It is desirable that educators, parents, social workers and, of course, physicians benefit from these newer mental hygiene concepts of recreation.

A TREASURY OF DOCTOR STORIES BY THE WORLD'S GREAT AUTHORS. Compiled by *Noah D. Fabricant* and *Heinz Werner.* Cloth. Pp. 493. Price, $3.00. New York: Frederick Fell, 1946.

In this unique collection of stories you will find thirty-five pieces that reflect the moods, sentiments and behavior of doctors and nurses living their personal as well as their professional lives. Here are stories factual and imaginary, whimsical and robust, serious and humorous, touching and gay, but with one common element: the uniform excellence of their literary craftsmanship.

A surprising number of the literary great of all countries have at one time or another written about the medical scene. Here for the first time the intriguing, delightful, dramatic and all-absorbing by such masters of narrative as A. J. Cronin, Somerset Maugham, Ernest Hemingway, Erskine Caldwell, Pearl Buck, Irwin S. Cobb, Jack London, Ben Hecht and many others have been combined into a volume loaded with great stories about doctors.

The authors have not been interested primarily in the medical scene but in a tale well told. It is interesting to note that without relaxing their literary standards these stories maintain a real medical interest. As a matter of fact only a few of the authors have had formal medical education. A number of the stories have been accorded recognition for their outstanding merit.

The medical scene is so far-flung in all of its ramifications that it is very difficult, if not impossible to define what material an anthology covering it should include. An encyclopedic anthology, one dealing with all human ailments and depicting physicians in all their aspects, would be theoretically ideal, but in fact, profoundly boring. This collection of doctor stories is by no means all-inclusive and is a book of permanent enjoyment. It is highly recommended for anyone who loves good reading.

PHYSICAL MEDICINE ABSTRACTS

Sources of Ultraviolet and Infra-Red Radiation Used in Therapy—Physical Characteristics. W. W. Coblentz.

J. A. M. A. **132**:378 (Oct. 19) 1946.

So far as is known, the effect of infra-red radiation is entirely thermal. Recent studies of temperature sensation by Oppel and Hardy show that nonpenetrating infra-red radiation of long wavelengths is the most stimulating. This probably explains why discomfort is sometimes experienced when one is exposed to certain types of heaters which emit an excessive amount of nonpenetrating infra-red radiation.

When the arc is covered with a suitable glass chimney which absorbs the ultraviolet rays shorter than 2,900 angstroms and the infra-red rays longer than 40,000 angstroms, the white flame carbon arc is the closest approach to sunlight. But it is still far from being an exact match with sunlight in spectral energy distribution. It remains to be determined whether this difference in spectral energy distribution is of importance biologically.

But few sources of radiation remain unexpected for therapeutic purposes. A recent European production is a so-called cold red light emitted by the neon glow discharge tube, familiar to all in the form of the sign-lighting tubes in show windows and street signs. The intensity of the total radiation emitted by the neon glass lamp is low. From the clinical tests made by Cramer and Fechner with a neon glow lamp intended for therapeutic purposes, it appears that the cold red ray lamp has little, if any, specific stimulating effect on the human body.

The fluorescence excited by filtered ultraviolet radiation is finding a wide variety of uses by amateurs and by professional workers in examining minerals and documents as well as in theatrical entertainments and the like; also in the examination and diagnosis and as a guide in the treatment of ringworm infection of the scalp. The source of ultraviolet is a high vapor pressure, "hot" mercury arc lamp. The filter enclosure consists of a red-purple glass that transmits principally the powerful emission line of wavelength 3,663 angstroms and a less amount of the emission line of 4,055 angstroms.

In general, the specifications by the Council have tended to improve the output of responsible lamp manufacturers, but at present there seems to be no means to prevent the exploitation of the public by the sale of cheap lamps emitting little or no ultraviolet radiation and by the sale of so-called "sun lamps" which emit ultraviolet radiation of wavelengths shorter than 2,900 angstroms (not present in sunlight) and which are dangerous because they produce conjunctivitis and, with excessive exposures, may cause coagulation of albumin (cataract).

Further Studies on Ultraviolet Radiation in Surgery. Roy Fraser.

Canad. M. A. J. **55**:457 (Nov.) 1946.

The extensive and increasing adoption of protective equipment seems to be due to the recognition by hospital authorities of four facts: The development of aerobiologic studies and the consequent understanding of the importance of airborne microorganisms in medicine, surgery and public health; the efficiency of ultraviolet germicidal radiation as demonstrated both experimentally and in widespread practical use; the safety of such radiation when tested by experimental methods and clinical experience, provided the proper precautions are observed at all times; the acceptance of the Council on Physical Medicine of the American Medical Association of standard ultraviolet equipment for the uses stated in such approval and under the standards and limitations given therein.

Use of ultraviolet germicidal equipment in hospitals and other institutions is widely increasing. The results of further experimental operations to test the safety of field irradiation are reported in condensed form. Safety measures for the protection of the patient and operating staff are described and stressed.

Seesaw Resuscitation for Treatment of Asphyxia in Newborn. R. S. Millen, and J. Davies.

Am. J. Obst. & Gynec. **52**:508 (Sept.) 1946.

Millen and Davies used the seesaw method described by Eve in asphyxia of a premature infant. In this method the position of the body is alternated frequently by rocking on a trestle, so as to allow the weight of the liver and abdominal contents to drop downward and thus pull air into the lungs when the head is raised and the feet lowered, and the reverse to take place, causing expulsion of air from the lungs when the head is lowered and the feet raised. The child's head was lowered, and immediately the familiar thick mucous plug was expelled through the child's nostrils. Alternate rocking of the child transferred and removed the weight of the abdominal viscera to the diaphragm and thereby established a nontraumatic pulmonary ventilation.

Optimism in Medicine. William D. Stroud.

J. A. M. A. **132**:361 (Oct. 19) 1946.

It has seemed to the author that more youngsters have been made miserable and parents unhappy through physicians' serious attitudes toward unimportant heart murmurs than such

youngsters have been made invalids because of rheumatic heart disease. From the standpoint of murmurs the author would like to urge physicians to take an optimistic attitude and permit children to live happy lives rather than prohibit them from carrying on the activities of youth which give so much happiness.

Many persons have unnecessarily been made blood pressure conscious with pressures only slightly above normal. There is no proof that tobacco causes atherosclerosis or arteriosclerosis, and Stroud believes it is perfectly safe to smoke.

Two of the most important forms of treatment in the case of acute myocardial infarction are rest and reassurance. The average patient with a healed coronary occlusion can return to a sedentary occupation part time in about three months. Although it is debatable, because of the possibility of further occlusions, it is safe to allow such patients to drive a car three months or so after their acute episode.

Many physicians advise patients with hypertension or coronary artery disease or any form of heart disease not to drink. The author sees no reason why patients with these conditions should not drink in moderation.

Treatment of Sacroiliac Sprain by Manipulation. A. M. Bidwell.

J. Florida M. A. 33:193 (Oct.) 1946.

Sacroiliac sprain is a definite entity. It is, in fact, the major cause of low back pain. This type of sprain occurs gradually as the development of relaxation and postural strain alters the mechanical and static forces of bodily equilibrium between the trunk and the lower extremities, or it develops suddenly as a result of some traumatic event. When the onset is gradual, referred pain does not develop for some time; when the onset is sudden, there is a history of an awkward movement resulting in a sitich low in the back. Sacroiliac sprain also sometimes accompanies crushing injuries of the spine or pelvis or both. In these cases, when pain continues to be present over the sacroiliac joint, it usually is still displaced, and after manipulation the pain disappears. Anatomically, this joint has a wide irregular surface, the shifting of which even in slight degree produces symptoms of subluxation.

The characteristic features of sacroiliac sprain are recounted, and a method of treatment by manipulation is described. A series of 146 cases is presented in which this therapy produced spectacular results, greatly reducing the average period of treatment and effecting recovery in 96 per cent of the cases.

Susceptibility to Colds—An Experimental Investigation Amongst Factory Workers. J. P. P. Stock.

Brit. J. Phys. Med. 9:145 (Sept.-Oct.) 1946.

The purpose of this paper is to present clinical evidence of a close association between susceptibility to colds and chronic catarrhal conditions of the upper respiratory tract. Evidence is presented also that improvement of chronic upper respiratory catarrh in "cold" susceptible subjects following treatment is accompanied in the majority of cases by a corresponding reduction in both the frequency and severity of their colds.

Coincident with the first cycle of the nebulants, a routine course of 12 graduated shortwave treatments is given: 3 each week, spread over four weeks.

After completing the shortwave treatments the patient is instructed to continue with the spraying cycle and is subsequently re-examined in the clinic at intervals of two or three months. If progress is not satisfactory, or if relapse of symptoms occurs, second and occasionally third courses of shortwave treatment are given.

In approximately two-thirds of the number of cases receiving this treatment symptomatic improvement begins towards the end of the first week and reaches a peak about 2 weeks after the completion of the first course of 12 shortwave treatments. Subsequent return of symptoms occurs in about half the number of cases, more particularly in those patients who have allowed their spraying to lapse. These relapses often appear first after a cold, or symptoms may begin to reappear gradually several weeks after the spraying was stopped. In the majority of cases, restarting the spraying cycle leads to quick remission of symptoms and restoration of the previous improved level. In some instances, however, improvement is delayed until a further course of short-wave treatment has been given.

In all, 377 cases were treated in the clinic during the period under review and a questionnaire was sent to each patient; 278 completed questionnaires were returned to the clinic.

Tinea Capitis—Its Treatment With Special Iodine and Dilute Acetic Acid. Albert Strickler.

J. A. M. A. 132:65 (Sept. 14) 1946.

The principles involved in this method concern the use of iodine, a remedial agent acknowledged as definitely fungistatic and to a degree fungicidal for the ringworm fungus, and the enhancement of this activity through the application of photosynthesis, whereby it is assumed that the iodine molecule became a more active molecule (an activated molecule). At the onset of this consideration it is important to bear in mind that the fundamental reaction in photosynthesis is a photochemical one and that for its consummation a number of factors are required.

The quartz mercury vapor arc lamp was used with most of its energy in the 2,600 to 2,900 angstrom level. This was applied at a distance of 6 inches from the container for a time sufficient to dry the material.

The treatment followed in both series consisted in clipping the hair of the scalp and keeping it short. The topical applications consisted in the use of acetic acid and of the iodine combination. First the acetic acid is rubbed into the scalp with a tooth brush for two minutes, with particular attention to the infected areas. Next an electric

bulb of 150 to 200 watt strength is kept sufficiently close to the scalp to impart a distinct sensation of heat for two minutes. Then the iodine and oil combination is rubbed into the scalp with friction for two minutes by means of another tooth brush, and this is followed by the application of heat from the electric bulb for six minutes. These treatments are given twice daily. The scalp is washed every other day. The use of heat from the electric bulb following the application of the iodine is for the purpose of possibly inducing some vaporization of the iodine, for substances in vapor form are rather easily absorbed.

In the combined series of 115 children with tinea capitis, 74 patients (64 per cent) were cured as determined by three successive direct negative examinations and by three negative inspections of the scalp hair under filtered ultraviolet light.

Rehabilitation of the Surgical Patient in Army Hospitals in World War II. Augustus Thorndike.

Am. J. Surg. **72**:404 (Sept.) 1946.

Among the interesting developments of surgery of the recent war and evident as of interest in prior wars was the importance of developing as part of medical treatment a planned program of convalescent reconditioning. The forgotten surgical patient in civil practice is he who has been discharged from the hospital to the home care of relatives for the convalescent period. The Surgeon General in 1943 fully appreciated the problem relative to the soldier patient, who, when discharged from the hospital must be physically fit to report for a full day's military duty or discharged to civil status fit to assume the full responsibilities of independent economic life.

With a good program of convalescent reconditioning, many patients have been returned to full military duty that otherwise would only have been capable of performing limited duty; and, furthermore, large numbers have been salvaged for limited duty that otherwise would have been discharged to civil life. In the recent war 58.8 per cent of the wounded were returned to military duty within the overseas theaters—an important number of military personnel too have been salvaged.

Electrotherapy of the Levator Muscle of the Anus (Levator Ani) During the Postpartum Period and in Some Gynecologic Conditions. Henri Vignes, and Luce A. Langevin.

West. J. Surg. **54**:394 (Oct.) 1946.

In modern times it has been the practice for women to remain in bed for a period of time after delivery. For some time it has been proposed to make early rising after delivery easier by reducing the risk of genital prolapse, often ascribed to this procedure. The first idea in the investigations of the authors was to encourage the involution of the perineum and the levator ani and the muscular tissues at the base of the broad ligaments by electric gymnastics, thus, giving the muscles new training, employing the nutritive effect of galvanic current.

The apparatus used was set up by M. Andre Langevin, Professor at the School of Physics and Chemistry. There was used a bowled metallic electrode (one centimeter in diameter), which is introduced into the rectum so that it reaches the upper portion of the levator ani as near the motor point as possible, where the muscle receives its innervation (gluteal and retroanal applications proved to be less successful). An external ebonite ball, rigidly connected with the inner silvered copper ball through an ebonite rod, allows the inner electrode to maintain a steady position.

The other external electrode is made up of a large conducting plate (15 by 20 cm.) on which are laid a fine felt cover and a chamois soaked in normal saline. This electrode is placed either right above the pubis as near the fibers of the inner part of the levator ani as possible, or in the posttrochanteric region so that the current runs through the sciatic notch along the external fibers of the muscle.

An inexpensive therapeutic device has been reported which may be of value in restoring muscle tone to structures during not only the postpartum period but in the gynecologic patient as well. Further use of the galvanic current may bring more supporting evidence.

Diet and Man's Tolerance to Cold.

Edit. J. A. M. A. **132**:716 (Nov. 23) 1946.

The possibility that human tolerance to cold may be affected by diet, particularly by the water soluble vitamins, has been a matter of conjecture for many years. Recently a comprehensive study of the question has been reported by a group of investigators at the University of Illinois.

These careful studies thus indicate clearly that the ability of man to withstand the damaging effects of repeated exposures to cold cannot be appreciably altered by giving excessive doses of ascorbic acid, thiamine, riboflavin and nicotinic acid above the amounts required for apparently normal nutrition. The possibility that the water soluble vitamins might show a favorable effect in subjects with definite avitaminosis, of course, is not answered by these experiments.

Electric Shock Therapy of Elderly Patients. F. Feldman; S. Susselman; B. Lipetz and S. E. Barrera.

Arch. Neurol. & Psychiat. **56**:158 (Aug.) 1946.

Feldman and his associates present observations on 53 patients over 65 years of age who were subjected to shock treatment. The significance of an impaired cardiovascular system in the patient with serious mental illness must be evaluated in terms of what the future holds for the patient with and without treatment. When a diagnosis other than senile dementia can be made in a patient over 65, especially that of depressive, manic or paranoid psychosis, electric shock treatment should be considered. The only contraindications should be extreme defects in the physical state, particularly in the cardiovascular system. The value of the treatment is seen in the high proportion of patients returned to their homes as either recovered or much improved.

Psychosomatic Aspects of Arterial Hypertension. Edward Weiss, and Morris Kleinbart.
Pennsylvania M. J. **49**:1321 (Sept.) 1946.

The organic tradition in medicine has been responsible for a narrow view of the etiology and treatment of essential hypertension. The psychosomatic approach does not neglect the physical problems involved, but includes a consideration of the role of the emotions. It does not mean to study the soma less; it means to study the psyche more. It emphasizes the multiple factors in etiology and pathogenesis and attempts to evaluate the resulting composite clinical picture. Such studies indicate that emotional factors apparently are intimately related to the development of hypertension in some patients, to the production of symptoms in many others, and enter into the question of treatment in nearly all patients with essential hypertension.

A common problem seems to be the presence of emotional tension due to chronic repressed hostility. This inhibited aggression (chronic rage) seems to bear a definite relationship to hypertension and if it can be relieved by means of psychotherapy, anxiety is diminished and blood pressure is often lowered. Even if the blood pressure is unaffected, the treatment usually benefits the patient by making him a healthier and more effective personality. Our objectives in treatment should be readjusted. We must not limit our efforts to "bringing the blood pressure down." There is no reason why physical (medical and surgical) methods cannot be combined with psychotherapy, but one must go beyond the physical aspects of hypertension to the personality of the hypertensive individual in order to be successful in the management of such patients.

Recent Advances in Ophthalmology. Benjamin Rones.
M. Ann. District Columbia **15**:473 (Oct.) 1946.

A debunking report of considerable significance has recently been sponsored by Woods from the Wilmer Institute. This concerns the treatment of myopia by visual training, a method which has been given wide publicity by the optometric profession. The visual acuity without correction was recorded for each case in a series of 103 myopic individuals, a cycloplegic was instilled and retinoscopic and static refractions were determined. The patients were then turned over to a group of optometrists and psychologists for a course of visual training designed to improve their uncorrected vision. In 30 patients (29 per cent) a low-grade improvement was noted. In 31 patients (30 per cent) no consistent improvement could be demonstrated, but an over-all improvement in both eyes was observed. The improvement in these two groups was not consistently maintained. In 32 patients (31 per cent) no change in percentage visual acuity could be demonstrated. In 10 patients (9 per cent) there was a decrease in percentage visual acuity. These changes in percentage visual acuity were within the limits of error of subjective testing of visual acuity. The author concluded that except for the improvement in interpreting blurred images and a beneficial psychologic reaction toward the handicap, there was no demonstrable value to visual training as a method of treatment for myopia.

Rehabilitation of the Tuberculous in Industry. Norvin C. Kiefer, and Herman E. Hilleboe.
J. A. M. A. **132**:121 (Sept. 21) 1946.

Rehabilitation and aftercare must be preceded by adequate diagnostic facilities and proper medical treatment. Unfortunately, however, there is as yet insufficient realization of the fact that, without rehabilitation and after-care, much or all of the time, effort and money spent on diagnosis and treatment will be wasted.

Rehabilitation in tuberculosis is the restoration of tuberculous persons to the fullest physical, mental, social, vocational and economic usefulness of which they are capable. Vocational rehabilitation, which is only one phase of the complete process of rehabilitation, was defined as meaning any services necessary to render a tuberculous person fit to engage in an occupation suitable to health and aptitude.

A number of studies indicate that the tuberculous ex-patient is a satisfactory employee. Any increase absenteeism attributable to illness and the necessity for special attention to even minor complaints is equalized by a decrease in absenteeism that results from nonmedical causes. A rather common experience of employers is that the tuberculous ex-patient is more loyal than the average well employee. Whether this is a consequence of gratitude for having received employment, of fear of losing a job or other factors is irrelevant.

It does not seem unfair, therefore, to believe that an employer is obligated to reinstate any former employee who has recovered sufficiently from tuberculosis. This statement remains true even when, at first, the ex-patient and ex-employee is able to start at only four hours' work per day and may have to be placed at work which is more suitable to his physical limitations. Even these disadvantages may be more than compensated by the broadening of the scope of activities of the Office of Vocational Rehabilitation. Many of these employees, as a result of insanatorium and early postsanatorium instruction and training, will return to their jobs better qualified and more productive than they were before the onset of the disease.

Arthritis. Philip S. Hench.
J. A. M. A. **132**:974 (Dec. 21) 1946.

In cases of rheumatoid arthritis no significant results have been obtained from penicillin, neostigmine (prostigmine), physostigmine or concentrated vitamins, including ertron. Chrysotherapy is still on trial. Many experienced rheumatologists continue to regard it as the best single treatment now available and believe that, despite the risk of occasional serious toxic reactions, its use is justified in cases of progressive rheumatoid arthritis.

For rheumatoid spondylitis roentgen therapy appears to be the remedy of choice but should be combined with postural and deep breathing exercises.